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(54) Title: ANTISENSE MODULATION OF APOLIPOPROTEIN B EXPRESSION

(57) Abstract: Antisense compounds, compositions and methods are provided for modulating the expression of apolipoprotein B. The compositions comprise antisense compounds, particularly antisense oligonucleotides, targeted to nucleic acids encoding apolipoprotein B. Methods of using these compounds for modulation of apolipoprotein B expression and for treatment of diseases associated with expression of apolipoprotein B are provided.



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ANTISENSE MODULATION OF APOLIPOPROTEIN B EXPRESSION**5 FIELD OF THE INVENTION**

The present invention provides compositions and methods for modulating the expression of apolipoprotein B. In particular, this invention relates to compounds, particularly oligonucleotides, specifically hybridizable
10 with nucleic acids encoding apolipoprotein B. Such compounds have been shown to modulate the expression of apolipoprotein B.

BACKGROUND OF THE INVENTION

Lipoproteins are globular, micelle-like particles
15 that consist of a non-polar core of acylglycerols and cholesteryl esters surrounded by an amphiphilic coating of protein, phospholipid and cholesterol. Lipoproteins have been classified into five broad categories on the basis of their functional and physical properties: chylomicrons,
20 which transport dietary lipids from intestine to tissues; very low density lipoproteins (VLDL); intermediate density lipoproteins (IDL); low density lipoproteins (LDL); all of which transport triacylglycerols and cholesterol from the liver to tissues; and high density lipoproteins (HDL),
25 which transport endogenous cholesterol from tissues to the liver.

Lipoprotein particles undergo continuous metabolic processing and have variable properties and compositions. Lipoprotein densities increase without decreasing particle
30 diameter because the density of their outer coatings is

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less than that of the inner core. The protein components of lipoproteins are known as apolipoproteins. At least nine apolipoproteins are distributed in significant amounts among the various human lipoproteins.

5 Apolipoprotein B (also known as ApoB, apolipoprotein B-100; ApoB-100, apolipoprotein B-48; ApoB-48 and Ag(x) antigen), is a large glycoprotein that serves an indispensable role in the assembly and secretion of lipids and in the transport and receptor-mediated uptake and
10 delivery of distinct classes of lipoproteins. The importance of apolipoprotein B spans a variety of functions, from the absorption and processing of dietary lipids to the regulation of circulating lipoprotein levels (Davidson and Shelness, *Annu. Rev. Nutr.*, 2000, 20, 169-
15 193). This latter property underlies its relevance in terms of atherosclerosis susceptibility, which is highly correlated with the ambient concentration of apolipoprotein B-containing lipoproteins (Davidson and Shelness, *Annu. Rev. Nutr.*, 2000, 20, 169-193).

20 Two forms of apolipoprotein B exist in mammals. ApoB-100 represents the full-length protein containing 4536 amino acid residues synthesized exclusively in the human liver (Davidson and Shelness, *Annu. Rev. Nutr.*, 2000, 20, 169-193). A truncated form known as ApoB-48 is colinear
25 with the amino terminal 2152 residues and is synthesized in the small intestine of all mammals (Davidson and Shelness, *Annu. Rev. Nutr.*, 2000, 20, 169-193).

 ApoB-100 is the major protein component of LDL and contains the domain required for interaction of this
30 lipoprotein species with the LDL receptor. In addition, ApoB-100 contains an unpaired cysteine residue which mediates an interaction with apolipoprotein(a) and generates another distinct atherogenic lipoprotein called

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Lp(a) (Davidson and Shelness, *Annu. Rev. Nutr.*, 2000, 20, 169-193).

In humans, ApoB-48 circulates in association with chylomicrons and chylomicron remnants and these particles are cleared by a distinct receptor known as the LDL-receptor-related protein (Davidson and Shelness, *Annu. Rev. Nutr.*, 2000, 20, 169-193). ApoB-48 can be viewed as a crucial adaptation by which dietary lipid is delivered from the small intestine to the liver, while ApoB-100 participates in the transport and delivery of endogenous plasma cholesterol (Davidson and Shelness, *Annu. Rev. Nutr.*, 2000, 20, 169-193).

The basis by which the common structural gene for apolipoprotein B produces two distinct protein isoforms is a process known as RNA editing. A site specific cytosine-to-uracil editing reaction produces a UAA stop codon and translational termination of apolipoprotein B to produce ApoB-48 (Davidson and Shelness, *Annu. Rev. Nutr.*, 2000, 20, 169-193).

Apolipoprotein B was cloned in 1985 (Law et al., *Proc. Natl. Acad. Sci. U. S. A.*, 1985, 82, 8340-8344) and mapped to chromosome 2p23-2p24 in 1986 (Deeb et al., *Proc. Natl. Acad. Sci. U. S. A.*, 1986, 83, 419-422).

Disclosed and claimed in US patent 5,786,206 are methods and compositions for determining the level of low density lipoproteins (LDL) in plasma which include isolated DNA sequences encoding epitope regions of apolipoprotein B-100 (Smith et al., 1998).

Transgenic mice expressing human apolipoprotein B and fed a high-fat diet were found to develop high plasma cholesterol levels and displayed an 11-fold increase in atherosclerotic lesions over non-transgenic littermates

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(Kim and Young, *J. Lipid Res.*, 1998, 39, 703-723; Nishina et al., *J. Lipid Res.*, 1990, 31, 859-869).

In addition, transgenic mice expressing truncated forms of human apolipoprotein B have been employed to
5 identify the carboxyl-terminal structural features of ApoB-100 that are required for interactions with apolipoprotein(a) to generate the Lp(a) lipoprotein particle and to investigate structural features of the LDL receptor-binding region of ApoB-100 (Kim and Young, *J.*
10 *Lipid Res.*, 1998, 39, 703-723; McCormick et al., *J. Biol. Chem.*, 1997, 272, 23616-23622).

Apolipoprotein B knockout mice (bearing disruptions of both ApoB-100 and ApoB-48) have been generated which are protected from developing hypercholesterolemia when
15 fed a high-fat diet (Farese et al., *Proc. Natl. Acad. Sci. U. S. A.*, 1995, 92, 1774-1778; Kim and Young, *J. Lipid Res.*, 1998, 39, 703-723). The incidence of atherosclerosis has been investigated in mice expressing exclusively ApoB-100 or ApoB-48 and susceptibility to atherosclerosis was
20 found to be dependent on total cholesterol levels. Whether the mice synthesized ApoB-100 or ApoB-48 did not affect the extent of the atherosclerosis, indicating that there is probably no major difference in the intrinsic atherogenicity of ApoB-100 versus ApoB-48 (Kim and Young,
25 *J. Lipid Res.*, 1998, 39, 703-723; Veniant et al., *J. Clin. Invest.*, 1997, 100, 180-188).

Elevated plasma levels of the ApoB-100-containing lipoprotein Lp(a) are associated with increased risk for atherosclerosis and its manifestations, which may include
30 hypercholesterolemia (Seed et al., *N. Engl. J. Med.*, 1990, 322, 1494-1499), myocardial infarction (Sandkamp et al., *Clin. Chem.*, 1990, 36, 20-23), and thrombosis (Nowak-Gottl et al., *Pediatrics*, 1997, 99, E11).

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The plasma concentration of Lp(a) is strongly influenced by heritable factors and is refractory to most drug and dietary manipulation (Katan and Beynen, *Am. J. Epidemiol.*, **1987**, 125, 387-399; Vessby et al., *Atherosclerosis*, **1982**, 44, 61-71). Pharmacologic therapy of elevated Lp(a) levels has been only modestly successful and apheresis remains the most effective therapeutic modality (Hajjar and Nachman, *Annu. Rev. Med.*, **1996**, 47, 423-442).

Disclosed and claimed in US patent 6,156,315 and the corresponding PCT publication WO 99/18986 is a method for inhibiting the binding of LDL to blood vessel matrix in a subject, comprising administering to the subject an effective amount of an antibody or a fragment thereof, which is capable of binding to the amino-terminal region of apolipoprotein B, thereby inhibiting the binding of low density lipoprotein to blood vessel matrix (Goldberg and Pillarisetti, **2000**; Goldberg and Pillarisetti, **1999**).

Disclosed and claimed in US patent 6,096,516 are vectors containing cDNA encoding murine recombinant antibodies which bind to human ApoB-100 for the purpose of for diagnosis and treatment of cardiovascular diseases (Kwak et al., **2000**).

Disclosed and claimed in PCT publication EP 911344 is a monoclonal antibody which specifically binds to ApoB-48 and does not specifically bind to ApoB-100, which is useful for diagnosis and therapy of hyperlipidemia and arterial sclerosis (Uchida and Kurano, **1998**).

Disclosed and claimed in PCT publication WO 01/30354 are methods of treating a patient with a cardiovascular disorder, comprising administering a therapeutically effective amount of a compound to said patient, wherein said compound acts for a period of time to lower plasma

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concentrations of apolipoprotein B or apolipoprotein B-containing lipoproteins by stimulating a pathway for apolipoprotein B degradation (Fisher and Williams, 2001).

Disclosed and claimed in US patent 5,220,006 is a
5 cloned *cis*-acting DNA sequence that mediates the suppression of atherogenic apolipoprotein B (Ross et al., 1993).

Disclosed and claimed in PCT publication WO 01/12789 is a ribozyme which cleaves ApoB-100 mRNA specifically at
10 position 6679 (Chan et al., 2001).

To date, strategies aimed at inhibiting apolipoprotein B function have been limited to Lp(a) apheresis, antibodies, antibody fragments and ribozymes. However, with the exception of Lp(a) apheresis, these
15 investigative strategies are untested as therapeutic protocols. Consequently, there remains a long felt need for additional agents capable of effectively inhibiting apolipoprotein B function.

Antisense technology is emerging as an effective
20 means of reducing the expression of specific gene products and may therefore prove to be uniquely useful in a number of therapeutic, diagnostic and research applications involving modulation of apolipoprotein B expression.

The present invention provides compositions and
25 methods for modulating apolipoprotein B expression, including inhibition of the alternative isoform of apolipoprotein B, ApoB-48.

SUMMARY OF THE INVENTION

The present invention is directed to compounds,
30 particularly antisense oligonucleotides, which are targeted to a nucleic acid encoding apolipoprotein B, and which modulate the expression of apolipoprotein B. Pharmaceutical and other compositions comprising the

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compounds of the invention are also provided. Further provided are methods of modulating the expression of apolipoprotein B in cells or tissues comprising contacting said cells or tissues with one or more of the antisense
5 compounds or compositions of the invention. Further provided are methods of treating an animal, particularly a human, suspected of having or being prone to a disease or condition associated with expression of apolipoprotein B by administering a therapeutically or prophylactically
10 effective amount of one or more of the antisense compounds or compositions of the invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention employs oligomeric compounds, particularly antisense oligonucleotides, for use in
15 modulating the function of nucleic acid molecules encoding apolipoprotein B, ultimately modulating the amount of apolipoprotein B produced. This is accomplished by providing antisense compounds which specifically hybridize with one or more nucleic acids encoding apolipoprotein B.
20 As used herein, the terms "target nucleic acid" and "nucleic acid encoding apolipoprotein B" encompass DNA encoding apolipoprotein B, RNA (including pre-mRNA and mRNA) transcribed from such DNA, and also cDNA derived from such RNA. The specific hybridization of an
25 oligomeric compound with its target nucleic acid interferes with the normal function of the nucleic acid. This modulation of function of a target nucleic acid by compounds which specifically hybridize to it is generally referred to as "antisense". The functions of DNA to be
30 interfered with include replication and transcription. The functions of RNA to be interfered with include all vital functions such as, for example, translocation of the RNA to the site of protein translation, translation of

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protein from the RNA, splicing of the RNA to yield one or more mRNA species, and catalytic activity which may be engaged in or facilitated by the RNA. The overall effect of such interference with target nucleic acid function is modulation of the expression of apolipoprotein B. In the context of the present invention, "modulation" means either an increase (stimulation) or a decrease (inhibition) in the expression of a gene. In the context of the present invention, inhibition is the preferred form of modulation of gene expression and mRNA is a preferred target.

It is preferred to target specific nucleic acids for antisense. "Targeting" an antisense compound to a particular nucleic acid, in the context of this invention, is a multistep process. The process usually begins with the identification of a nucleic acid sequence whose function is to be modulated. This may be, for example, a cellular gene (or mRNA transcribed from the gene) whose expression is associated with a particular disorder or disease state, or a nucleic acid molecule from an infectious agent. In the present invention, the target is a nucleic acid molecule encoding apolipoprotein B. The targeting process also includes determination of a site or sites within this gene for the antisense interaction to occur such that the desired effect, e.g., detection or modulation of expression of the protein, will result. Within the context of the present invention, a preferred intragenic site is the region encompassing the translation initiation or termination codon of the open reading frame (ORF) of the gene. Since, as is known in the art, the translation initiation codon is typically 5'-AUG (in transcribed mRNA molecules; 5'-ATG in the corresponding DNA molecule), the translation initiation codon is also

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referred to as the "AUG codon," the "start codon" or the "AUG start codon". A minority of genes have a translation initiation codon having the RNA sequence 5'-GUG, 5'-UUG or 5'-CUG, and 5'-AUA, 5'-ACG and 5'-CUG have been shown to
5 function *in vivo*. Thus, the terms "translation initiation codon" and "start codon" can encompass many codon sequences, even though the initiator amino acid in each instance is typically methionine (in eukaryotes) or formylmethionine (in prokaryotes). It is also known in
10 the art that eukaryotic and prokaryotic genes may have two or more alternative start codons, any one of which may be preferentially utilized for translation initiation in a particular cell type or tissue, or under a particular set of conditions. In the context of the invention, "start
15 codon" and "translation initiation codon" refer to the codon or codons that are used *in vivo* to initiate translation of an mRNA molecule transcribed from a gene encoding apolipoprotein B, regardless of the sequence(s) of such codons.

20 It is also known in the art that a translation termination codon (or "stop codon") of a gene may have one of three sequences, i.e., 5'-UAA, 5'-UAG and 5'-UGA (the corresponding DNA sequences are 5'-TAA, 5'-TAG and 5'-TGA, respectively). The terms "start codon region" and
25 "translation initiation codon region" refer to a portion of such an mRNA or gene that encompasses from about 25 to about 50 contiguous nucleotides in either direction (i.e., 5' or 3') from a translation initiation codon. Similarly, the terms "stop codon region" and "translation termination
30 codon region" refer to a portion of such an mRNA or gene that encompasses from about 25 to about 50 contiguous nucleotides in either direction (i.e., 5' or 3') from a translation termination codon.

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The open reading frame (ORF) or "coding region," which is known in the art to refer to the region between the translation initiation codon and the translation termination codon, is also a region which may be targeted effectively. Other target regions include the 5' untranslated region (5'UTR), known in the art to refer to the portion of an mRNA in the 5' direction from the translation initiation codon, and thus including nucleotides between the 5' cap site and the translation initiation codon of an mRNA or corresponding nucleotides on the gene, and the 3' untranslated region (3'UTR), known in the art to refer to the portion of an mRNA in the 3' direction from the translation termination codon, and thus including nucleotides between the translation termination codon and 3' end of an mRNA or corresponding nucleotides on the gene. The 5' cap of an mRNA comprises an N7-methylated guanosine residue joined to the 5'-most residue of the mRNA via a 5'-5' triphosphate linkage. The 5' cap region of an mRNA is considered to include the 5' cap structure itself as well as the first 50 nucleotides adjacent to the cap. The 5' cap region may also be a preferred target region.

Although some eukaryotic mRNA transcripts are directly translated, many contain one or more regions, known as "introns," which are excised from a transcript before it is translated. The remaining (and therefore translated) regions are known as "exons" and are spliced together to form a continuous mRNA sequence. mRNA splice sites, i.e., intron-exon junctions, may also be preferred target regions, and are particularly useful in situations where aberrant splicing is implicated in disease, or where an overproduction of a particular mRNA splice product is implicated in disease. Aberrant fusion junctions due to

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rearrangements or deletions are also preferred targets. It has also been found that introns can also be effective, and therefore preferred, target regions for antisense compounds targeted, for example, to DNA or pre-mRNA.

5 Once one or more target sites have been identified, oligonucleotides are chosen which are sufficiently complementary to the target, i.e., hybridize sufficiently well and with sufficient specificity, to give the desired effect.

10 In the context of this invention, "hybridization" means hydrogen bonding, which may be Watson-Crick, Hoogsteen or reversed Hoogsteen hydrogen bonding, between complementary nucleoside or nucleotide bases. For example, adenine and thymine are complementary nucleobases
15 which pair through the formation of hydrogen bonds.

"Complementary," as used herein, refers to the capacity for precise pairing between two nucleotides. For example, if a nucleotide at a certain position of an oligonucleotide is capable of hydrogen bonding with a
20 nucleotide at the same position of a DNA or RNA molecule, then the oligonucleotide and the DNA or RNA are considered to be complementary to each other at that position. The oligonucleotide and the DNA or RNA are complementary to each other when a sufficient number of corresponding
25 positions in each molecule are occupied by nucleotides which can hydrogen bond with each other. Thus, "specifically hybridizable" and "complementary" are terms which are used to indicate a sufficient degree of complementarity or precise pairing such that stable and
30 specific binding occurs between the oligonucleotide and the DNA or RNA target. It is understood in the art that the sequence of an antisense compound need not be 100% complementary to that of its target nucleic acid to be

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specifically hybridizable. An antisense compound is specifically hybridizable when binding of the compound to the target DNA or RNA molecule interferes with the normal function of the target DNA or RNA to cause a loss of utility, and there is a sufficient degree of complementarity to avoid non-specific binding of the antisense compound to non-target sequences under conditions in which specific binding is desired, i.e., under physiological conditions in the case of *in vivo* assays or therapeutic treatment, and in the case of *in vitro* assays, under conditions in which the assays are performed.

Antisense and other compounds of the invention which hybridize to the target and inhibit expression of the target are identified through experimentation, and the sequences of these compounds are hereinbelow identified as preferred embodiments of the invention. The target sites to which these preferred sequences are complementary are hereinbelow referred to as "active sites" and are therefore preferred sites for targeting. Therefore another embodiment of the invention encompasses compounds which hybridize to these active sites.

Antisense compounds are commonly used as research reagents and diagnostics. For example, antisense oligonucleotides, which are able to inhibit gene expression with exquisite specificity, are often used by those of ordinary skill to elucidate the function of particular genes. Antisense compounds are also used, for example, to distinguish between functions of various members of a biological pathway. Antisense modulation has, therefore, been harnessed for research use.

For use in kits and diagnostics, the antisense compounds of the present invention, either alone or in

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combination with other antisense compounds or therapeutics, can be used as tools in differential and/or combinatorial analyses to elucidate expression patterns of a portion or the entire complement of genes expressed within cells and tissues.

Expression patterns within cells or tissues treated with one or more antisense compounds are compared to control cells or tissues not treated with antisense compounds and the patterns produced are analyzed for differential levels of gene expression as they pertain, for example, to disease association, signaling pathway, cellular localization, expression level, size, structure or function of the genes examined. These analyses can be performed on stimulated or unstimulated cells and in the presence or absence of other compounds which affect expression patterns.

Examples of methods of gene expression analysis known in the art include DNA arrays or microarrays (Brazma and Vilo, *FEBS Lett.*, 2000, 480, 17-24; Celis, et al., *FEBS Lett.*, 2000, 480, 2-16), SAGE (serial analysis of gene expression) (Madden, et al., *Drug Discov. Today*, 2000, 5, 415-425), READS (restriction enzyme amplification of digested cDNAs) (Prashar and Weissman, *Methods Enzymol.*, 1999, 303, 258-72), TOGA (total gene expression analysis) (Sutcliffe, et al., *Proc. Natl. Acad. Sci. U. S. A.*, 2000, 97, 1976-81), protein arrays and proteomics (Celis, et al., *FEBS Lett.*, 2000, 480, 2-16; Jungblut, et al., *Electrophoresis*, 1999, 20, 2100-10), expressed sequence tag (EST) sequencing (Celis, et al., *FEBS Lett.*, 2000, 480, 2-16; Larsson, et al., *J. Biotechnol.*, 2000, 80, 143-57), subtractive RNA fingerprinting (SuRF) (Fuchs, et al., *Anal. Biochem.*, 2000, 286, 91-98; Larson, et al., *Cytometry*, 2000, 41, 203-208), subtractive cloning,

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differential display (DD) (Jurecic and Belmont, *Curr. Opin. Microbiol.*, **2000**, 3, 316-21), comparative genomic hybridization (Carulli, et al., *J. Cell Biochem. Suppl.*, **1998**, 31, 286-96), FISH (fluorescent in situ
5 hybridization) techniques (Going and Gusterson, *Eur. J. Cancer*, **1999**, 35, 1895-904) and mass spectrometry methods (reviewed in (To, *Comb. Chem. High Throughput Screen*, **2000**, 3, 235-41).

The specificity and sensitivity of antisense is also
10 harnessed by those of skill in the art for therapeutic uses. Antisense oligonucleotides have been employed as therapeutic moieties in the treatment of disease states in animals and man. Antisense oligonucleotide drugs,
including ribozymes, have been safely and effectively
15 administered to humans and numerous clinical trials are presently underway. It is thus established that oligonucleotides can be useful therapeutic modalities that can be configured to be useful in treatment regimes for treatment of cells, tissues and animals, especially
20 humans.

In the context of this invention, the term "oligonucleotide" refers to an oligomer or polymer of ribonucleic acid (RNA) or deoxyribonucleic acid (DNA) or mimetics thereof. This term includes oligonucleotides
25 composed of naturally-occurring nucleobases, sugars and covalent internucleoside (backbone) linkages as well as oligonucleotides having non-naturally-occurring portions which function similarly. Such modified or substituted oligonucleotides are often preferred over native forms
30 because of desirable properties such as, for example, enhanced cellular uptake, enhanced affinity for nucleic acid target and increased stability in the presence of nucleases.

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While antisense oligonucleotides are a preferred form of antisense compound, the present invention comprehends other oligomeric antisense compounds, including but not limited to oligonucleotide mimetics such as are described below. The antisense compounds in accordance with this invention preferably comprise from about 8 to about 50 nucleobases (i.e. from about 8 to about 50 linked nucleosides). Particularly preferred antisense compounds are antisense oligonucleotides, even more preferably those comprising from about 12 to about 30 nucleobases. Antisense compounds include ribozymes, external guide sequence (EGS) oligonucleotides (oligozymes), and other short catalytic RNAs or catalytic oligonucleotides which hybridize to the target nucleic acid and modulate its expression.

As is known in the art, a nucleoside is a base-sugar combination. The base portion of the nucleoside is normally a heterocyclic base. The two most common classes of such heterocyclic bases are the purines and the pyrimidines. Nucleotides are nucleosides that further include a phosphate group covalently linked to the sugar portion of the nucleoside. For those nucleosides that include a pentofuranosyl sugar, the phosphate group can be linked to either the 2', 3' or 5' hydroxyl moiety of the sugar. In forming oligonucleotides, the phosphate groups covalently link adjacent nucleosides to one another to form a linear polymeric compound. In turn the respective ends of this linear polymeric structure can be further joined to form a circular structure, however, open linear structures are generally preferred. Within the oligonucleotide structure, the phosphate groups are commonly referred to as forming the internucleoside backbone of the oligonucleotide. The normal linkage or

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backbone of RNA and DNA is a 3' to 5' phosphodiester linkage.

Specific examples of preferred antisense compounds useful in this invention include oligonucleotides
5 containing modified backbones or non-natural internucleoside linkages. As defined in this specification, oligonucleotides having modified backbones include those that retain a phosphorus atom in the backbone and those that do not have a phosphorus atom in
10 the backbone. For the purposes of this specification, and as sometimes referenced in the art, modified oligonucleotides that do not have a phosphorus atom in their internucleoside backbone can also be considered to be oligonucleosides.

15 Preferred modified oligonucleotide backbones include, for example, phosphorothioates, chiral phosphorothioates, phosphorodithioates, phosphotriesters, aminoalkyl-phosphotriesters, methyl and other alkyl phosphonates including 3'-alkylene phosphonates, 5'-alkylene
20 phosphonates and chiral phosphonates, phosphinates, phosphoramidates including 3'-amino phosphoramidate and aminoalkylphosphoramidates, thionophosphoramidates, thionoalkylphosphonates, thionoalkylphosphotriesters, selenophosphates and boranophosphates having normal 3'-5'
25 linkages, 2'-5' linked analogs of these, and those having inverted polarity wherein one or more internucleotide linkages is a 3' to 3', 5' to 5' or 2' to 2' linkage. Preferred oligonucleotides having inverted polarity comprise a single 3' to 3' linkage at the 3'-most
30 internucleotide linkage i.e. a single inverted nucleoside residue which may be abasic (the nucleobase is missing or has a hydroxyl group in place thereof). Various salts, mixed salts and free acid forms are also included.

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Representative United States patents that teach the preparation of the above phosphorus-containing linkages include, but are not limited to, U.S.: 3,687,808; 4,469,863; 4,476,301; 5,023,243; 5,177,196; 5,188,897; 5,264,423; 5,276,019; 5,278,302; 5,286,717; 5,321,131; 5,399,676; 5,405,939; 5,453,496; 5,455,233; 5,466,677; 5,476,925; 5,519,126; 5,536,821; 5,541,306; 5,550,111; 5,563,253; 5,571,799; 5,587,361; 5,194,599; 5,565,555; 5,527,899; 5,721,218; 5,672,697 and 5,625,050, certain of which are commonly owned with this application, and each of which is herein incorporated by reference.

Preferred modified oligonucleotide backbones that do not include a phosphorus atom therein have backbones that are formed by short chain alkyl or cycloalkyl internucleoside linkages, mixed heteroatom and alkyl or cycloalkyl internucleoside linkages, or one or more short chain heteroatomic or heterocyclic internucleoside linkages. These include those having morpholino linkages (formed in part from the sugar portion of a nucleoside); siloxane backbones; sulfide, sulfoxide and sulfone backbones; formacetyl and thioformacetyl backbones; methylene formacetyl and thioformacetyl backbones; riboacetyl backbones; alkene containing backbones; sulfamate backbones; methyleneimino and methylenehydrazino backbones; sulfonate and sulfonamide backbones; amide backbones; and others having mixed N, O, S and CH₂ component parts.

Representative United States patents that teach the preparation of the above oligonucleosides include, but are not limited to, U.S.: 5,034,506; 5,166,315; 5,185,444; 5,214,134; 5,216,141; 5,235,033; 5,264,562; 5,264,564; 5,405,938; 5,434,257; 5,466,677; 5,470,967; 5,489,677; 5,541,307; 5,561,225; 5,596,086; 5,602,240; 5,610,289;

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5,602,240; 5,608,046; 5,610,289; 5,618,704; 5,623,070;
5,663,312; 5,633,360; 5,677,437; 5,792,608; 5,646,269 and
5,677,439, certain of which are commonly owned with this
application, and each of which is herein incorporated by
5 reference.

In other preferred oligonucleotide mimetics, both the
sugar and the internucleoside linkage, i.e., the backbone,
of the nucleotide units are replaced with novel groups.
The base units are maintained for hybridization with an
10 appropriate nucleic acid target compound. One such
oligomeric compound, an oligonucleotide mimetic that has
been shown to have excellent hybridization properties, is
referred to as a peptide nucleic acid (PNA). In PNA
compounds, the sugar-backbone of an oligonucleotide is
15 replaced with an amide containing backbone, in particular
an aminoethylglycine backbone. The nucleobases are
retained and are bound directly or indirectly to aza
nitrogen atoms of the amide portion of the backbone.
Representative United States patents that teach the
20 preparation of PNA compounds include, but are not limited
to, U.S.: 5,539,082; 5,714,331; and 5,719,262, each of
which is herein incorporated by reference. Further
teaching of PNA compounds can be found in Nielsen et al.,
Science, 1991, 254, 1497-1500.

25 Most preferred embodiments of the invention are
oligonucleotides with phosphorothioate backbones and
oligonucleosides with heteroatom backbones, and in
particular -CH₂-NH-O-CH₂-, -CH₂-N(CH₃)-O-CH₂- [known as a
methylene (methylimino) or MMI backbone], -CH₂-O-N(CH₃)-
30 CH₂-, -CH₂-N(CH₃)-N(CH₃)-CH₂- and -O-N(CH₃)-CH₂-CH₂- [wherein
the native phosphodiester backbone is represented as -O-P-
O-CH₂-] of the above referenced U.S. patent 5,489,677, and
the amide backbones of the above referenced U.S. patent

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5,602,240. Also preferred are oligonucleotides having morpholino backbone structures of the above-referenced U.S. patent 5,034,506.

Modified oligonucleotides may also contain one or
5 more substituted sugar moieties. Preferred
oligonucleotides comprise one of the following at the 2'
position: OH; F; O-, S-, or N-alkyl; O-, S-, or N-alkenyl;
O-, S- or N-alkynyl; or O-alkyl-O-alkyl, wherein the
alkyl, alkenyl and alkynyl may be substituted or
10 unsubstituted C₁ to C₁₀ alkyl or C₂ to C₁₀ alkenyl and
alkynyl. Particularly preferred are O[(CH₂)_nO]_mCH₃,
O(CH₂)_nOCH₃, O(CH₂)_nNH₂, O(CH₂)_nCH₃, O(CH₂)_nONH₂, and
O(CH₂)_nON[(CH₂)_nCH₃]₂, where n and m are from 1 to about
10. Other preferred oligonucleotides comprise one of the
15 following at the 2' position: C₁ to C₁₀ lower alkyl,
substituted lower alkyl, alkenyl, alkynyl, alkaryl,
aralkyl, O-alkaryl or O-aralkyl, SH, SCH₃, OCN, Cl, Br, CN,
CF₃, OCF₃, SOCH₃, SO₂CH₃, ONO₂, NO₂, N₃, NH₂,
heterocycloalkyl, heterocycloalkaryl, aminoalkylamino,
20 polyalkylamino, substituted silyl, an RNA cleaving group,
a reporter group, an intercalator, a group for improving
the pharmacokinetic properties of an oligonucleotide, or a
group for improving the pharmacodynamic properties of an
oligonucleotide, and other substituents having similar
25 properties. A preferred modification includes 2'-
methoxyethoxy (2'-O-CH₂CH₂OCH₃, also known as 2'-O-(2-
methoxyethyl) or 2'-MOE) (Martin et al., *Helv. Chim. Acta*,
1995, 78, 486-504) i.e., an alkoxyalkoxy group. A further
preferred modification includes 2'-dimethylaminoethoxy,
30 i.e., a O(CH₂)₂ON(CH₃)₂ group, also known as 2'-DMAOE, as
described in examples hereinbelow, and 2'-dimethylamino-
ethoxyethoxy (also known in the art as 2'-O-dimethylamino-
ethoxyethyl or 2'-DMAEOE), i.e., 2'-O-CH₂-O-CH₂-N(CH₂)₂,

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also described in examples hereinbelow.

A further preferred modification includes Locked Nucleic Acids (LNAs) in which the 2'-hydroxyl group is linked to the 3' or 4' carbon atom of the sugar ring thereby forming a bicyclic sugar moiety. The linkage is preferably a methylene $(-\text{CH}_2-)_n$ group bridging the 2' oxygen atom and the 4' carbon atom wherein n is 1 or 2. LNAs and preparation thereof are described in WO 98/39352 and WO 99/14226.

Other preferred modifications include 2'-methoxy (2'-O-CH₃), 2'-aminopropoxy (2'-OCH₂CH₂CH₂NH₂), 2'-allyl (2'-CH₂-CH=CH₂), 2'-O-allyl (2'-O-CH₂-CH=CH₂) and 2'-fluoro (2'-F). The 2'-modification may be in the arabino (up) position or ribo (down) position. A preferred 2'-arabino modification is 2'-F. Similar modifications may also be made at other positions on the oligonucleotide, particularly the 3' position of the sugar on the 3' terminal nucleotide or in 2'-5' linked oligonucleotides and the 5' position of 5' terminal nucleotide.

Oligonucleotides may also have sugar mimetics such as cyclobutyl moieties in place of the pentofuranosyl sugar. Representative United States patents that teach the preparation of such modified sugar structures include, but are not limited to, U.S.: 4,981,957; 5,118,800; 5,319,080; 5,359,044; 5,393,878; 5,446,137; 5,466,786; 5,514,785; 5,519,134; 5,567,811; 5,576,427; 5,591,722; 5,597,909; 5,610,300; 5,627,053; 5,639,873; 5,646,265; 5,658,873; 5,670,633; 5,792,747; and 5,700,920, certain of which are commonly owned with the instant application, and each of which is herein incorporated by reference in its entirety.

Oligonucleotides may also include nucleobase (often referred to in the art simply as "base") modifications or substitutions. As used herein, "unmodified" or "natural"

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nucleobases include the purine bases adenine (A) and guanine (G), and the pyrimidine bases thymine (T), cytosine (C) and uracil (U). Modified nucleobases include other synthetic and natural nucleobases such as 5-methylcytosine (5-me-C), 5-hydroxymethyl cytosine, xanthine, hypoxanthine, 2-aminoadenine, 6-methyl and other alkyl derivatives of adenine and guanine, 2-propyl and other alkyl derivatives of adenine and guanine, 2-thiouracil, 2-thiothymine and 2-thiocytosine, 5-halouracil and cytosine, 5-propynyl ($-C\equiv C-CH_3$) uracil and cytosine and other alkynyl derivatives of pyrimidine bases, 6-azouracil, cytosine and thymine, 5-uracil (pseudouracil), 4-thiouracil, 8-halo, 8-amino, 8-thiol, 8-thioalkyl, 8-hydroxyl and other 8-substituted adenines and guanines, 5-halo particularly 5-bromo, 5-trifluoromethyl and other 5-substituted uracils and cytosines, 7-methylguanine and 7-methyladenine, 2-F-adenine, 2-amino-adenine, 8-azaguanine and 8-azaadenine, 7-deazaguanine and 7-deazaadenine and 3-deazaguanine and 3-deazaadenine. Further modified nucleobases include tricyclic pyrimidines such as phenoxazine cytidine (1H-pyrimido[5,4-b][1,4]benzoxazin-2(3H)-one), phenothiazine cytidine (1H-pyrimido[5,4-b][1,4]benzothiazin-2(3H)-one), G-clamps such as a substituted phenoxazine cytidine (e.g. 9-(2-aminoethoxy)-H-pyrimido[5,4-b][1,4]benzoxazin-2(3H)-one), carbazole cytidine (2H-pyrimido[4,5-b]indol-2-one), pyridoindole cytidine (H-pyrido[3',2':4,5]pyrrolo[2,3-d]pyrimidin-2-one). Modified nucleobases may also include those in which the purine or pyrimidine base is replaced with other heterocycles, for example 7-deaza-adenine, 7-deazaguanosine, 2-aminopyridine and 2-pyridone. Further nucleobases include those disclosed in United States Patent No. 3,687,808, those disclosed in *The Concise*

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Encyclopedia Of Polymer Science And Engineering, pages 858-859, Kroschwitz, J.I., ed. John Wiley & Sons, 1990, those disclosed by Englisch et al., *Angewandte Chemie*, International Edition, 1991, 30, 613, and those disclosed
5 by Sanghvi, Y.S., Chapter 15, *Antisense Research and Applications*, pages 289-302, Crooke, S.T. and Lebleu, B. , ed., CRC Press, 1993. Certain of these nucleobases are particularly useful for increasing the binding affinity of the oligomeric compounds of the invention. These include
10 5-substituted pyrimidines, 6-azapyrimidines and N-2, N-6 and O-6 substituted purines, including 2-aminopropyl-adenine, 5-propynyluracil and 5-propynylcytosine. 5-methylcytosine substitutions have been shown to increase nucleic acid duplex stability by 0.6-1.2°C (Sanghvi, Y.S.,
15 Crooke, S.T. and Lebleu, B., eds., *Antisense Research and Applications*, CRC Press, Boca Raton, 1993, pp. 276-278) and are presently preferred base substitutions, even more particularly when combined with 2'-O-methoxyethyl sugar modifications.

20 Representative United States patents that teach the preparation of certain of the above noted modified nucleobases as well as other modified nucleobases include, but are not limited to, the above noted U.S. 3,687,808, as well as U.S.: 4,845,205; 5,130,302; 5,134,066; 5,175,273;
25 5,367,066; 5,432,272; 5,457,187; 5,459,255; 5,484,908; 5,502,177; 5,525,711; 5,552,540; 5,587,469; 5,594,121, 5,596,091; 5,614,617; 5,645,985; 5,830,653; 5,763,588; 6,005,096; and 5,681,941, certain of which are commonly owned with the instant application, and each of which is
30 herein incorporated by reference, and United States patent 5,750,692, which is commonly owned with the instant application and also herein incorporated by reference.

Another modification of the oligonucleotides of the

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invention involves chemically linking to the oligonucleotide one or more moieties or conjugates which enhance the activity, cellular distribution or cellular uptake of the oligonucleotide. The compounds of the invention can include conjugate groups covalently bound to functional groups such as primary or secondary hydroxyl groups. Conjugate groups of the invention include intercalators, reporter molecules, polyamines, polyamides, polyethylene glycols, polyethers, groups that enhance the pharmacodynamic properties of oligomers, and groups that enhance the pharmacokinetic properties of oligomers. Typical conjugates groups include cholesterols, lipids, phospholipids, biotin, phenazine, folate, phenanthridine, anthraquinone, acridine, fluoresceins, rhodamines, coumarins, and dyes. Groups that enhance the pharmacodynamic properties, in the context of this invention, include groups that improve oligomer uptake, enhance oligomer resistance to degradation, and/or strengthen sequence-specific hybridization with RNA. Groups that enhance the pharmacokinetic properties, in the context of this invention, include groups that improve oligomer uptake, distribution, metabolism or excretion. Representative conjugate groups are disclosed in International Patent Application PCT/US92/09196, filed October 23, 1992 the entire disclosure of which is incorporated herein by reference. Conjugate moieties include but are not limited to lipid moieties such as a cholesterol moiety (Letsinger et al., *Proc. Natl. Acad. Sci. USA*, **1989**, *86*, 6553-6556), cholic acid (Manoharan et al., *Bioorg. Med. Chem. Let.*, **1994**, *4*, 1053-1060), a thioether, e.g., hexyl-S-tritylthiol (Manoharan et al., *Ann. N.Y. Acad. Sci.*, **1992**, *660*, 306-309; Manoharan et al., *Bioorg. Med. Chem. Let.*, **1993**, *3*, 2765-2770), a

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thiocholesterol (Oberhauser et al., *Nucl. Acids Res.*,
1992, 20, 533-538), an aliphatic chain, e.g., dodecandiol
or undecyl residues (Saison-Behmoaras et al., *EMBO J.*,
1991, 10, 1111-1118; Kabanov et al., *FEBS Lett.*, 1990,
5 259, 327-330; Svinarchuk et al., *Biochimie*, 1993, 75, 49-
54), a phospholipid, e.g., di-hexadecyl-rac-glycerol or
triethylammonium 1,2-di-O-hexadecyl-rac-glycero-3-H-
phosphonate (Manoharan et al., *Tetrahedron Lett.*, 1995,
36, 3651-3654; Shea et al., *Nucl. Acids Res.*, 1990, 18,
10 3777-3783), a polyamine or a polyethylene glycol chain
(Manoharan et al., *Nucleosides & Nucleotides*, 1995, 14,
969-973), or adamantane acetic acid (Manoharan et al.,
Tetrahedron Lett., 1995, 36, 3651-3654), a palmityl moiety
(Mishra et al., *Biochim. Biophys. Acta*, 1995, 1264, 229-
15 237), or an octadecylamine or hexylamino-carbonyl-
oxycholesterol moiety (Crooke et al., *J. Pharmacol. Exp.*
Ther., 1996, 277, 923-937. Oligonucleotides of the
invention may also be conjugated to active drug
substances, for example, aspirin, warfarin, phenylbuta-
20 zone, ibuprofen, suprofen, fenbufen, ketoprofen, (S)-(+)-
pranoprofen, carprofen, dansylsarcosine, 2,3,5-triiodo-
benzoic acid, flufenamic acid, folinic acid, a
benzothiadiazide, chlorothiazide, a diazepine, indo-
methicin, a barbiturate, a cephalosporin, a sulfa drug, an
25 antidiabetic, an antibacterial or an antibiotic.

Oligonucleotide-drug conjugates and their preparation are
described in United States Patent Application 09/334,130
(filed June 15, 1999) which is incorporated herein by
reference in its entirety.

30 Representative United States patents that teach the
preparation of such oligonucleotide conjugates include,
but are not limited to, U.S.: 4,828,979; 4,948,882;
5,218,105; 5,525,465; 5,541,313; 5,545,730; 5,552,538;

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5,578,717, 5,580,731; 5,580,731; 5,591,584; 5,109,124;
5,118,802; 5,138,045; 5,414,077; 5,486,603; 5,512,439;
5,578,718; 5,608,046; 4,587,044; 4,605,735; 4,667,025;
4,762,779; 4,789,737; 4,824,941; 4,835,263; 4,876,335;
5 4,904,582; 4,958,013; 5,082,830; 5,112,963; 5,214,136;
5,082,830; 5,112,963; 5,214,136; 5,245,022; 5,254,469;
5,258,506; 5,262,536; 5,272,250; 5,292,873; 5,317,098;
5,371,241, 5,391,723; 5,416,203, 5,451,463; 5,510,475;
5,512,667; 5,514,785; 5,565,552; 5,567,810; 5,574,142;
10 5,585,481; 5,587,371; 5,595,726; 5,597,696; 5,599,923;
5,599,928 and 5,688,941, certain of which are commonly
owned with the instant application, and each of which is
herein incorporated by reference.

It is not necessary for all positions in a given
15 compound to be uniformly modified, and in fact more than
one of the aforementioned modifications may be
incorporated in a single compound or even at a single
nucleoside within an oligonucleotide. The present
invention also includes antisense compounds which are
20 chimeric compounds. "Chimeric" antisense compounds or
"chimeras," in the context of this invention, are
antisense compounds, particularly oligonucleotides, which
contain two or more chemically distinct regions, each made
up of at least one monomer unit, i.e., a nucleotide in the
25 case of an oligonucleotide compound. These
oligonucleotides typically contain at least one region
wherein the oligonucleotide is modified so as to confer
upon the oligonucleotide increased resistance to nuclease
degradation, increased cellular uptake, and/or increased
30 binding affinity for the target nucleic acid. An
additional region of the oligonucleotide may serve as a
substrate for enzymes capable of cleaving RNA:DNA or
RNA:RNA hybrids. By way of example, RNase H is a cellular

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endonuclease which cleaves the RNA strand of an RNA:DNA duplex. Activation of RNase H, therefore, results in cleavage of the RNA target, thereby greatly enhancing the efficiency of oligonucleotide inhibition of gene
5 expression. Consequently, comparable results can often be obtained with shorter oligonucleotides when chimeric oligonucleotides are used, compared to phosphorothioate deoxyoligonucleotides hybridizing to the same target region. Cleavage of the RNA target can be routinely
10 detected by gel electrophoresis and, if necessary, associated nucleic acid hybridization techniques known in the art.

Chimeric antisense compounds of the invention may be formed as composite structures of two or more
15 oligonucleotides, modified oligonucleotides, oligonucleosides and/or oligonucleotide mimetics as described above. Such compounds have also been referred to in the art as hybrids or gapmers. Representative United States patents that teach the preparation of such
20 hybrid structures include, but are not limited to, U.S.: 5,013,830; 5,149,797; 5,220,007; 5,256,775; 5,366,878; 5,403,711; 5,491,133; 5,565,350; 5,623,065; 5,652,355; 5,652,356; and 5,700,922, certain of which are commonly owned with the instant application, and each of which is
25 herein incorporated by reference in its entirety.

The antisense compounds used in accordance with this invention may be conveniently and routinely made through the well-known technique of solid phase synthesis. Equipment for such synthesis is sold by several vendors
30 including, for example, Applied Biosystems (Foster City, CA). Any other means for such synthesis known in the art may additionally or alternatively be employed. It is well known to use similar techniques to prepare

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oligonucleotides such as the phosphorothioates and alkylated derivatives.

The antisense compounds of the invention are synthesized *in vitro* and do not include antisense
5 compositions of biological origin, or genetic vector constructs designed to direct the *in vivo* synthesis of antisense molecules.

The compounds of the invention may also be admixed, encapsulated, conjugated or otherwise associated with
10 other molecules, molecule structures or mixtures of compounds, as for example, liposomes, receptor targeted molecules, oral, rectal, topical or other formulations, for assisting in uptake, distribution and/or absorption. Representative United States patents that teach the
15 preparation of such uptake, distribution and/or absorption assisting formulations include, but are not limited to, U.S.: 5,108,921; 5,354,844; 5,416,016; 5,459,127; 5,521,291; 5,543,158; 5,547,932; 5,583,020; 5,591,721; 4,426,330; 4,534,899; 5,013,556; 5,108,921; 5,213,804;
20 5,227,170; 5,264,221; 5,356,633; 5,395,619; 5,416,016; 5,417,978; 5,462,854; 5,469,854; 5,512,295; 5,527,528; 5,534,259; 5,543,152; 5,556,948; 5,580,575; and 5,595,756, each of which is herein incorporated by reference.

The antisense compounds of the invention encompass
25 any pharmaceutically acceptable salts, esters, or salts of such esters, or any other compound which, upon administration to an animal including a human, is capable of providing (directly or indirectly) the biologically active metabolite or residue thereof. Accordingly, for
30 example, the disclosure is also drawn to prodrugs and pharmaceutically acceptable salts of the compounds of the invention, pharmaceutically acceptable salts of such prodrugs, and other bioequivalents.

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The term "prodrug" indicates a therapeutic agent that is prepared in an inactive form that is converted to an active form (i.e., drug) within the body or cells thereof by the action of endogenous enzymes or other chemicals and/or conditions. In particular, prodrug versions of the oligonucleotides of the invention are prepared as SATE [(S-acetyl-2-thioethyl) phosphate] derivatives according to the methods disclosed in WO 93/24510 to Gosselin et al., published December 9, 1993 or in WO 94/26764 and U.S. 5,770,713 to Imbach et al.

The term "pharmaceutically acceptable salts" refers to physiologically and pharmaceutically acceptable salts of the compounds of the invention: i.e., salts that retain the desired biological activity of the parent compound and do not impart undesired toxicological effects thereto.

Pharmaceutically acceptable base addition salts are formed with metals or amines, such as alkali and alkaline earth metals or organic amines. Examples of metals used as cations are sodium, potassium, magnesium, calcium, and the like. Examples of suitable amines are N,N'-dibenzylethylenediamine, chloroprocaine, choline, diethanolamine, dicyclohexylamine, ethylenediamine, N-methylglucamine, and procaine (see, for example, Berge et al., "Pharmaceutical Salts," *J. of Pharma Sci.*, 1977, 66, 1-19). The base addition salts of said acidic compounds are prepared by contacting the free acid form with a sufficient amount of the desired base to produce the salt in the conventional manner. The free acid form may be regenerated by contacting the salt form with an acid and isolating the free acid in the conventional manner. The free acid forms differ from their respective salt forms somewhat in certain physical properties such as solubility in polar solvents, but otherwise the salts are

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equivalent to their respective free acid for purposes of the present invention. As used herein, a "pharmaceutical addition salt" includes a pharmaceutically acceptable salt of an acid form of one of the components of the

5 compositions of the invention. These include organic or inorganic acid salts of the amines. Preferred acid salts are the hydrochlorides, acetates, salicylates, nitrates and phosphates. Other suitable pharmaceutically acceptable salts are well known to those skilled in the

10 art and include basic salts of a variety of inorganic and organic acids, such as, for example, with inorganic acids, such as for example hydrochloric acid, hydrobromic acid, sulfuric acid or phosphoric acid; with organic carboxylic, sulfonic, sulfo or phospho acids or N-substituted sulfamic

15 acids, for example acetic acid, propionic acid, glycolic acid, succinic acid, maleic acid, hydroxymaleic acid, methylemaleic acid, fumaric acid, malic acid, tartaric acid, lactic acid, oxalic acid, gluconic acid, glucaric acid, glucuronic acid, citric acid, benzoic acid, cinnamic

20 acid, mandelic acid, salicylic acid, 4-aminosalicylic acid, 2-phenoxybenzoic acid, 2-acetoxybenzoic acid, embonic acid, nicotinic acid or isonicotinic acid; and with amino acids, such as the 20 alpha-amino acids involved in the synthesis of proteins in nature, for

25 example glutamic acid or aspartic acid, and also with phenylacetic acid, methanesulfonic acid, ethanesulfonic acid, 2-hydroxyethanesulfonic acid, ethane-1,2-disulfonic acid, benzenesulfonic acid, 4-methylbenzenesulfonic acid, naphthalene-2-sulfonic acid, naphthalene-1,5-disulfonic

30 acid, 2- or 3-phosphoglycerate, glucose-6-phosphate, N-cyclohexylsulfamic acid (with the formation of cyclamates), or with other acid organic compounds, such as ascorbic acid. Pharmaceutically acceptable salts of

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compounds may also be prepared with a pharmaceutically acceptable cation. Suitable pharmaceutically acceptable cations are well known to those skilled in the art and include alkaline, alkaline earth, ammonium and quaternary ammonium cations. Carbonates or hydrogen carbonates are also possible.

For oligonucleotides, preferred examples of pharmaceutically acceptable salts include but are not limited to (a) salts formed with cations such as sodium, potassium, ammonium, magnesium, calcium, polyamines such as spermine and spermidine, etc.; (b) acid addition salts formed with inorganic acids, for example hydrochloric acid, hydrobromic acid, sulfuric acid, phosphoric acid, nitric acid and the like; (c) salts formed with organic acids such as, for example, acetic acid, oxalic acid, tartaric acid, succinic acid, maleic acid, fumaric acid, gluconic acid, citric acid, malic acid, ascorbic acid, benzoic acid, tannic acid, palmitic acid, alginic acid, polyglutamic acid, naphthalenesulfonic acid, methanesulfonic acid, p-toluenesulfonic acid, naphthalenedisulfonic acid, polygalacturonic acid, and the like; and (d) salts formed from elemental anions such as chlorine, bromine, and iodine.

The antisense compounds of the present invention can be utilized for diagnostics, therapeutics, prophylaxis and as research reagents and kits. For therapeutics, an animal, preferably a human, suspected of having a disease or disorder which can be treated by modulating the expression of apolipoprotein B is treated by administering antisense compounds in accordance with this invention. The compounds of the invention can be utilized in pharmaceutical compositions by adding an effective amount of an antisense compound to a suitable pharmaceutically

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acceptable diluent or carrier. Use of the antisense compounds and methods of the invention may also be useful prophylactically, e.g., to prevent or delay infection, inflammation or tumor formation, for example.

5 The antisense compounds of the invention are useful for research and diagnostics, because these compounds hybridize to nucleic acids encoding apolipoprotein B, enabling sandwich and other assays to easily be constructed to exploit this fact. Hybridization of the
10 antisense oligonucleotides of the invention with a nucleic acid encoding apolipoprotein B can be detected by means known in the art. Such means may include conjugation of an enzyme to the oligonucleotide, radiolabelling of the oligonucleotide or any other suitable detection means.
15 Kits using such detection means for detecting the level of apolipoprotein B in a sample may also be prepared.

 The present invention also includes pharmaceutical compositions and formulations which include the antisense compounds of the invention. The pharmaceutical
20 compositions of the present invention may be administered in a number of ways depending upon whether local or systemic treatment is desired and upon the area to be treated. Administration may be topical (including ophthalmic and to mucous membranes including vaginal and
25 rectal delivery), pulmonary, e.g., by inhalation or insufflation of powders or aerosols, including by nebulizer; intratracheal, intranasal, epidermal and transdermal), oral or parenteral. Parenteral
administration includes intravenous, intraarterial,
30 subcutaneous, intraperitoneal or intramuscular injection or infusion; or intracranial, e.g., intrathecal or intraventricular, administration. Oligonucleotides with at least one 2'-O-methoxyethyl modification are believed

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to be particularly useful for oral administration.

Pharmaceutical compositions and formulations for topical administration may include transdermal patches, ointments, lotions, creams, gels, drops, suppositories, 5 sprays, liquids and powders. Conventional pharmaceutical carriers, aqueous, powder or oily bases, thickeners and the like may be necessary or desirable. Coated condoms, gloves and the like may also be useful. Preferred topical formulations include those in which the oligonucleotides 10 of the invention are in admixture with a topical delivery agent such as lipids, liposomes, fatty acids, fatty acid esters, steroids, chelating agents and surfactants. Preferred lipids and liposomes include neutral (e.g. dioleoylphosphatidyl DOPE ethanolamine, 15 dimyristoylphosphatidyl choline DMPC, distearoylphosphatidyl choline) negative (e.g. dimyristoylphosphatidyl glycerol DMPG) and cationic (e.g. dioleoyltetramethylaminopropyl DOTAP and dioleoylphosphatidyl ethanolamine DOTMA). 20 Oligonucleotides of the invention may be encapsulated within liposomes or may form complexes thereto, in particular to cationic liposomes. Alternatively, oligonucleotides may be complexed to lipids, in particular to cationic lipids. Preferred fatty acids and esters 25 include but are not limited arachidonic acid, oleic acid, eicosanoic acid, lauric acid, caprylic acid, capric acid, myristic acid, palmitic acid, stearic acid, linoleic acid, linolenic acid, dicaprate, tricaprate, monoolein, dilaurin, glyceryl 1-monocaprate, 30 1-dodecylazacycloheptan-2-one, an acylcarnitine, an acylcholine, or a C₁₋₁₀ alkyl ester (e.g. isopropylmyristate IPM), monoglyceride, diglyceride or pharmaceutically acceptable salt thereof. Topical

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formulations are described in detail in United States patent application 09/315,298 filed on May 20, 1999 which is incorporated herein by reference in its entirety.

Compositions and formulations for oral administration

5 include powders or granules, microparticulates, nanoparticulates, suspensions or solutions in water or non-aqueous media, capsules, gel capsules, sachets, tablets or minitables. Thickeners, flavoring agents, diluents, emulsifiers, dispersing aids or binders may be

10 desirable. Preferred oral formulations are those in which oligonucleotides of the invention are administered in conjunction with one or more penetration enhancers surfactants and chelators. Preferred surfactants include fatty acids and/or esters or salts thereof, bile acids

15 and/or salts thereof. Preferred bile acids/salts include chenodeoxycholic acid (CDCA) and ursodeoxychenodeoxycholic acid (UDCA), cholic acid, dehydrocholic acid, deoxycholic acid, glucolic acid, glycholic acid, glycodeoxycholic acid, taurocholic acid, taurodeoxycholic acid, sodium

20 tauro-24,25-dihydro-fusidate, sodium glycodihydrofusidate,. Preferred fatty acids include arachidonic acid, undecanoic acid, oleic acid, lauric acid, caprylic acid, capric acid, myristic acid, palmitic acid, stearic acid, linoleic acid, linolenic acid,

25 dicaprate, tricaprate, monoolein, dilaurin, glyceryl 1-monocaprate, 1-dodecylazacycloheptan-2-one, an acylcarnitine, an acylcholine, or a monoglyceride, a diglyceride or a pharmaceutically acceptable salt thereof (e.g. sodium). Also preferred are combinations of

30 penetration enhancers, for example, fatty acids/salts in combination with bile acids/salts. A particularly preferred combination is the sodium salt of lauric acid, capric acid and UDCA. Further penetration enhancers

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include polyoxyethylene-9-lauryl ether, polyoxyethylene-20-cetyl ether. Oligonucleotides of the invention may be delivered orally in granular form including sprayed dried particles, or complexed to form micro or nanoparticles.

5 Oligonucleotide complexing agents include poly-amino acids; polyimines; polyacrylates; polyalkylacrylates, polyoxethanes, polyalkylcyanoacrylates; cationized gelatins, albumins, starches, acrylates, polyethyleneglycols (PEG) and
10 starches; polyalkylcyanoacrylates; DEAE-derivatized polyimines, pollulans, celluloses and starches. Particularly preferred complexing agents include chitosan, N-trimethylchitosan, poly-L-lysine, polyhistidine, polyornithine, polyspermines, protamine,
15 polyvinylpyridine, polythiodiethylamino-methylethylene P(TDAE), polyaminostyrene (e.g. p-amino), poly(methylcyanoacrylate), poly(ethylcyanoacrylate), poly(butylcyanoacrylate), poly(isobutylcyanoacrylate), poly(isohexylcynaoacrylate), DEAE-methacrylate, DEAE-
20 hexylacrylate, DEAE-acrylamide, DEAE-albumin and DEAE-dextran, polymethylacrylate, polyhexylacrylate, poly(D,L-lactic acid), poly(DL-lactic-co-glycolic acid (PLGA), alginate, and polyethyleneglycol (PEG). Oral formulations for oligonucleotides and their preparation are described
25 in detail in United States applications 08/886,829 (filed July 1, 1997), 09/108,673 (filed July 1, 1998), 09/256,515 (filed February 23, 1999), 09/082,624 (filed May 21, 1998) and 09/315,298 (filed May 20, 1999) each of which is incorporated herein by reference in their entirety.

30 Compositions and formulations for parenteral, intrathecal or intraventricular administration may include sterile aqueous solutions which may also contain buffers, diluents and other suitable additives such as, but not

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limited to, penetration enhancers, carrier compounds and other pharmaceutically acceptable carriers or excipients.

Pharmaceutical compositions of the present invention include, but are not limited to, solutions, emulsions, and
5 liposome-containing formulations. These compositions may be generated from a variety of components that include, but are not limited to, preformed liquids, self-emulsifying solids and self-emulsifying semisolids.

The pharmaceutical formulations of the present
10 invention, which may conveniently be presented in unit dosage form, may be prepared according to conventional techniques well known in the pharmaceutical industry. Such techniques include the step of bringing into association the active ingredients with the pharmaceutical
15 carrier(s) or excipient(s). In general the formulations are prepared by uniformly and intimately bringing into association the active ingredients with liquid carriers or finely divided solid carriers or both, and then, if necessary, shaping the product.

20 The compositions of the present invention may be formulated into any of many possible dosage forms such as, but not limited to, tablets, capsules, gel capsules, liquid syrups, soft gels, suppositories, and enemas. The compositions of the present invention may also be
25 formulated as suspensions in aqueous, non-aqueous or mixed media. Aqueous suspensions may further contain substances which increase the viscosity of the suspension including, for example, sodium carboxymethylcellulose, sorbitol and/or dextran. The suspension may also contain
30 stabilizers.

In one embodiment of the present invention the pharmaceutical compositions may be formulated and used as foams. Pharmaceutical foams include formulations such as,

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but not limited to, emulsions, microemulsions, creams, jellies and liposomes. While basically similar in nature these formulations vary in the components and the consistency of the final product. The preparation of such compositions and formulations is generally known to those skilled in the pharmaceutical and formulation arts and may be applied to the formulation of the compositions of the present invention.

Emulsions

10 The compositions of the present invention may be prepared and formulated as emulsions. Emulsions are typically heterogenous systems of one liquid dispersed in another in the form of droplets usually exceeding 0.1 μm in diameter (Idson, in *Pharmaceutical Dosage Forms*,
15 Lieberman, Rieger and Banker (Eds.), 1988, Marcel Dekker, Inc., New York, N.Y., volume 1, p. 199; Rosoff, in *Pharmaceutical Dosage Forms*, Lieberman, Rieger and Banker (Eds.), 1988, Marcel Dekker, Inc., New York, N.Y., Volume 1, p. 245; Block in *Pharmaceutical Dosage Forms*,
20 Lieberman, Rieger and Banker (Eds.), 1988, Marcel Dekker, Inc., New York, N.Y., volume 2, p. 335; Higuchi et al., in *Remington's Pharmaceutical Sciences*, Mack Publishing Co., Easton, PA, 1985, p. 301). Emulsions are often biphasic systems comprising of two immiscible liquid phases
25 intimately mixed and dispersed with each other. In general, emulsions may be either water-in-oil (w/o) or of the oil-in-water (o/w) variety. When an aqueous phase is finely divided into and dispersed as minute droplets into a bulk oily phase the resulting composition is called a
30 water-in-oil (w/o) emulsion. Alternatively, when an oily phase is finely divided into and dispersed as minute droplets into a bulk aqueous phase the resulting composition is called an oil-in-water (o/w) emulsion.

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Emulsions may contain additional components in addition to the dispersed phases and the active drug which may be present as a solution in either the aqueous phase, oily phase or itself as a separate phase. Pharmaceutical
5 excipients such as emulsifiers, stabilizers, dyes, and anti-oxidants may also be present in emulsions as needed. Pharmaceutical emulsions may also be multiple emulsions that are comprised of more than two phases such as, for example, in the case of oil-in-water-in-oil (o/w/o) and
10 water-in-oil-in-water (w/o/w) emulsions. Such complex formulations often provide certain advantages that simple binary emulsions do not. Multiple emulsions in which individual oil droplets of an o/w emulsion enclose small water droplets constitute a w/o/w emulsion. Likewise a
15 system of oil droplets enclosed in globules of water stabilized in an oily continuous provides an o/w/o emulsion.

Emulsions are characterized by little or no thermodynamic stability. Often, the dispersed or
20 discontinuous phase of the emulsion is well dispersed into the external or continuous phase and maintained in this form through the means of emulsifiers or the viscosity of the formulation. Either of the phases of the emulsion may be a semisolid or a solid, as is the case of emulsion-
25 style ointment bases and creams. Other means of stabilizing emulsions entail the use of emulsifiers that may be incorporated into either phase of the emulsion. Emulsifiers may broadly be classified into four categories: synthetic surfactants, naturally occurring
30 emulsifiers, absorption bases, and finely dispersed solids (Idson, in *Pharmaceutical Dosage Forms*, Lieberman, Rieger and Banker (Eds.), 1988, Marcel Dekker, Inc., New York, N.Y., volume 1, p. 199).

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Synthetic surfactants, also known as surface active agents, have found wide applicability in the formulation of emulsions and have been reviewed in the literature (Rieger, in *Pharmaceutical Dosage Forms*, Lieberman, Rieger and Banker (Eds.), 1988, Marcel Dekker, Inc., New York, N.Y., volume 1, p. 285; Idson, in *Pharmaceutical Dosage Forms*, Lieberman, Rieger and Banker (Eds.), Marcel Dekker, Inc., New York, N.Y., 1988, volume 1, p. 199).

Surfactants are typically amphiphilic and comprise a hydrophilic and a hydrophobic portion. The ratio of the hydrophilic to the hydrophobic nature of the surfactant has been termed the hydrophile/lipophile balance (HLB) and is a valuable tool in categorizing and selecting surfactants in the preparation of formulations.

Surfactants may be classified into different classes based on the nature of the hydrophilic group: nonionic, anionic, cationic and amphoteric (Rieger, in *Pharmaceutical Dosage Forms*, Lieberman, Rieger and Banker (Eds.), 1988, Marcel Dekker, Inc., New York, N.Y., volume 1, p. 285).

Naturally occurring emulsifiers used in emulsion formulations include lanolin, beeswax, phosphatides, lecithin and acacia. Absorption bases possess hydrophilic properties such that they can soak up water to form w/o emulsions yet retain their semisolid consistencies, such as anhydrous lanolin and hydrophilic petrolatum. Finely divided solids have also been used as good emulsifiers especially in combination with surfactants and in viscous preparations. These include polar inorganic solids, such as heavy metal hydroxides, nonswelling clays such as bentonite, attapulgite, hectorite, kaolin, montmorillonite, colloidal aluminum silicate and colloidal magnesium aluminum silicate, pigments and nonpolar solids such as carbon or glyceryl tristearate.

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A large variety of non-emulsifying materials are also included in emulsion formulations and contribute to the properties of emulsions. These include fats, oils, waxes, fatty acids, fatty alcohols, fatty esters, humectants, hydrophilic colloids, preservatives and antioxidants (Block, in *Pharmaceutical Dosage Forms*, Lieberman, Rieger and Banker (Eds.), 1988, Marcel Dekker, Inc., New York, N.Y., volume 1, p. 335; Idson, in *Pharmaceutical Dosage Forms*, Lieberman, Rieger and Banker (Eds.), 1988, Marcel Dekker, Inc., New York, N.Y., volume 1, p. 199).

Hydrophilic colloids or hydrocolloids include naturally occurring gums and synthetic polymers such as polysaccharides (for example, acacia, agar, alginic acid, carrageenan, guar gum, karaya gum, and tragacanth), cellulose derivatives (for example, carboxymethylcellulose and carboxypropylcellulose), and synthetic polymers (for example, carbomers, cellulose ethers, and carboxyvinyl polymers). These disperse or swell in water to form colloidal solutions that stabilize emulsions by forming strong interfacial films around the dispersed-phase droplets and by increasing the viscosity of the external phase.

Since emulsions often contain a number of ingredients such as carbohydrates, proteins, sterols and phosphatides that may readily support the growth of microbes, these formulations often incorporate preservatives. Commonly used preservatives included in emulsion formulations include methyl paraben, propyl paraben, quaternary ammonium salts, benzalkonium chloride, esters of p-hydroxybenzoic acid, and boric acid. Antioxidants are also commonly added to emulsion formulations to prevent deterioration of the formulation. Antioxidants used may be free radical scavengers such as tocopherols, alkyl

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gallates, butylated hydroxyanisole, butylated hydroxytoluene, or reducing agents such as ascorbic acid and sodium metabisulfite, and antioxidant synergists such as citric acid, tartaric acid, and lecithin.

5 The application of emulsion formulations via dermatological, oral and parenteral routes and methods for their manufacture have been reviewed in the literature (Idson, in *Pharmaceutical Dosage Forms*, Lieberman, Rieger and Banker (Eds.), 1988, Marcel Dekker, Inc., New York,
10 N.Y., volume 1, p. 199). Emulsion formulations for oral delivery have been very widely used because of reasons of ease of formulation, efficacy from an absorption and bioavailability standpoint. (Rosoff, in *Pharmaceutical Dosage Forms*, Lieberman, Rieger and Banker (Eds.), 1988,
15 Marcel Dekker, Inc., New York, N.Y., volume 1, p. 245; Idson, in *Pharmaceutical Dosage Forms*, Lieberman, Rieger and Banker (Eds.), 1988, Marcel Dekker, Inc., New York, N.Y., volume 1, p. 199). Mineral-oil base laxatives, oil-soluble vitamins and high fat nutritive preparations are
20 among the materials that have commonly been administered orally as o/w emulsions.

 In one embodiment of the present invention, the compositions of oligonucleotides and nucleic acids are formulated as microemulsions. A microemulsion may be
25 defined as a system of water, oil and amphiphile which is a single optically isotropic and thermodynamically stable liquid solution (Rosoff, in *Pharmaceutical Dosage Forms*, Lieberman, Rieger and Banker (Eds.), 1988, Marcel Dekker, Inc., New York, N.Y., volume 1, p. 245). Typically
30 microemulsions are systems that are prepared by first dispersing an oil in an aqueous surfactant solution and then adding a sufficient amount of a fourth component, generally an intermediate chain-length alcohol to form a

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transparent system. Therefore, microemulsions have also been described as thermodynamically stable, isotropically clear dispersions of two immiscible liquids that are stabilized by interfacial films of surface-active molecules (Leung and Shah, in: *Controlled Release of Drugs: Polymers and Aggregate Systems*, Rosoff, M., Ed., 1989, VCH Publishers, New York, pages 185-215)..

Microemulsions commonly are prepared via a combination of three to five components that include oil, water, surfactant, cosurfactant and electrolyte. Whether the microemulsion is of the water-in-oil (w/o) or an oil-in-water (o/w) type is dependent on the properties of the oil and surfactant used and on the structure and geometric packing of the polar heads and hydrocarbon tails of the surfactant molecules (Schott, in *Remington's Pharmaceutical Sciences*, Mack Publishing Co., Easton, PA, 1985, p. 271).

The phenomenological approach utilizing phase diagrams has been extensively studied and has yielded a comprehensive knowledge, to one skilled in the art, of how to formulate microemulsions (Rosoff, in *Pharmaceutical Dosage Forms*, Lieberman, Rieger and Banker (Eds.), 1988, Marcel Dekker, Inc., New York, N.Y., volume 1, p. 245; Block, in *Pharmaceutical Dosage Forms*, Lieberman, Rieger and Banker (Eds.), 1988, Marcel Dekker, Inc., New York, N.Y., volume 1, p. 335). Compared to conventional emulsions, microemulsions offer the advantage of solubilizing water-insoluble drugs in a formulation of thermodynamically stable droplets that are formed spontaneously.

Surfactants used in the preparation of microemulsions include, but are not limited to, ionic surfactants, non-ionic surfactants, Brij 96, polyoxyethylene oleyl ethers,

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polyglycerol fatty acid esters, tetraglycerol monolaurate (ML310), tetraglycerol monooleate (MO310), hexaglycerol monooleate (PO310), hexaglycerol pentaoleate (PO500), decaglycerol monocaprate (MCA750), decaglycerol monooleate (MO750), decaglycerol sequioleate (SO750), decaglycerol decaoleate (DAO750), alone or in combination with cosurfactants. The cosurfactant, usually a short-chain alcohol such as ethanol, 1-propanol, and 1-butanol, serves to increase the interfacial fluidity by penetrating into the surfactant film and consequently creating a disordered film because of the void space generated among surfactant molecules. Microemulsions may, however, be prepared without the use of cosurfactants and alcohol-free self-emulsifying microemulsion systems are known in the art. The aqueous phase may typically be, but is not limited to, water, an aqueous solution of the drug, glycerol, PEG300, PEG400, polyglycerols, propylene glycols, and derivatives of ethylene glycol. The oil phase may include, but is not limited to, materials such as Captex 300, Captex 355, Capmul MCM, fatty acid esters, medium chain (C8-C12) mono, di, and tri-glycerides, polyoxyethylated glyceryl fatty acid esters, fatty alcohols, polyglycolized glycerides, saturated polyglycolized C8-C10 glycerides, vegetable oils and silicone oil.

Microemulsions are particularly of interest from the standpoint of drug solubilization and the enhanced absorption of drugs. Lipid based microemulsions (both o/w and w/o) have been proposed to enhance the oral bioavailability of drugs, including peptides (Constantinides et al., *Pharmaceutical Research*, 1994, 11, 1385-1390; Ritschel, *Meth. Find. Exp. Clin. Pharmacol.*, 1993, 13, 205). Microemulsions afford advantages of improved drug solubilization, protection of drug from

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enzymatic hydrolysis, possible enhancement of drug absorption due to surfactant-induced alterations in membrane fluidity and permeability, ease of preparation, ease of oral administration over solid dosage forms, improved clinical potency, and decreased toxicity (Constantinides et al., *Pharmaceutical Research*, 1994, 11, 1385; Ho et al., *J. Pharm. Sci.*, 1996, 85, 138-143). Often microemulsions may form spontaneously when their components are brought together at ambient temperature. This may be particularly advantageous when formulating thermolabile drugs, peptides or oligonucleotides. Microemulsions have also been effective in the transdermal delivery of active components in both cosmetic and pharmaceutical applications. It is expected that the microemulsion compositions and formulations of the present invention will facilitate the increased systemic absorption of oligonucleotides and nucleic acids from the gastrointestinal tract, as well as improve the local cellular uptake of oligonucleotides and nucleic acids within the gastrointestinal tract, vagina, buccal cavity and other areas of administration.

Microemulsions of the present invention may also contain additional components and additives such as sorbitan monostearate (Grill 3), Labrasol, and penetration enhancers to improve the properties of the formulation and to enhance the absorption of the oligonucleotides and nucleic acids of the present invention. Penetration enhancers used in the microemulsions of the present invention may be classified as belonging to one of five broad categories - surfactants, fatty acids, bile salts, chelating agents, and non-chelating non-surfactants (Lee et al., *Critical Reviews in Therapeutic Drug Carrier*

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Systems, 1991, p. 92). Each of these classes has been discussed above.

Liposomes

There are many organized surfactant structures
5 besides microemulsions that have been studied and used for the formulation of drugs. These include monolayers, micelles, bilayers and vesicles. Vesicles, such as liposomes, have attracted great interest because of their specificity and the duration of action they offer from the
10 standpoint of drug delivery. As used in the present invention, the term "liposome" means a vesicle composed of amphiphilic lipids arranged in a spherical bilayer or bilayers.

Liposomes are unilamellar or multilamellar vesicles
15 which have a membrane formed from a lipophilic material and an aqueous interior. The aqueous portion contains the composition to be delivered. Cationic liposomes possess the advantage of being able to fuse to the cell wall. Non-cationic liposomes, although not able to fuse as
20 efficiently with the cell wall, are taken up by macrophages *in vivo*.

In order to cross intact mammalian skin, lipid vesicles must pass through a series of fine pores, each with a diameter less than 50 nm, under the influence of a
25 suitable transdermal gradient. Therefore, it is desirable to use a liposome which is highly deformable and able to pass through such fine pores.

Further advantages of liposomes include; liposomes obtained from natural phospholipids are biocompatible and
30 biodegradable; liposomes can incorporate a wide range of water and lipid soluble drugs; liposomes can protect encapsulated drugs in their internal compartments from metabolism and degradation (Rosoff, in *Pharmaceutical*

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Dosage Forms, Lieberman, Rieger and Banker (Eds.), 1988, Marcel Dekker, Inc., New York, N.Y., volume 1, p. 245). Important considerations in the preparation of liposome formulations are the lipid surface charge, vesicle size
5 and the aqueous volume of the liposomes.

Liposomes are useful for the transfer and delivery of active ingredients to the site of action. Because the liposomal membrane is structurally similar to biological membranes, when liposomes are applied to a tissue, the
10 liposomes start to merge with the cellular membranes. As the merging of the liposome and cell progresses, the liposomal contents are emptied into the cell where the active agent may act.

Liposomal formulations have been the focus of
15 extensive investigation as the mode of delivery for many drugs. There is growing evidence that for topical administration, liposomes present several advantages over other formulations. Such advantages include reduced side-effects related to high systemic absorption of the
20 administered drug, increased accumulation of the administered drug at the desired target, and the ability to administer a wide variety of drugs, both hydrophilic and hydrophobic, into the skin.

Several reports have detailed the ability of
25 liposomes to deliver agents including high-molecular weight DNA into the skin. Compounds including analgesics, antibodies, hormones and high-molecular weight DNAs have been administered to the skin. The majority of applications resulted in the targeting of the upper
30 epidermis.

Liposomes fall into two broad classes. Cationic liposomes are positively charged liposomes which interact with the negatively charged DNA molecules to form a stable

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complex. The positively charged DNA/liposome complex binds to the negatively charged cell surface and is internalized in an endosome. Due to the acidic pH within the endosome, the liposomes are ruptured, releasing their contents into the cell cytoplasm (Wang et al., *Biochem. Biophys. Res. Commun.*, 1987, 147, 980-985).

Liposomes which are pH-sensitive or negatively-charged, entrap DNA rather than complex with it. Since both the DNA and the lipid are similarly charged, repulsion rather than complex formation occurs. Nevertheless, some DNA is entrapped within the aqueous interior of these liposomes. pH-sensitive liposomes have been used to deliver DNA encoding the thymidine kinase gene to cell monolayers in culture. Expression of the exogenous gene was detected in the target cells (Zhou et al., *Journal of Controlled Release*, 1992, 19, 269-274).

One major type of liposomal composition includes phospholipids other than naturally-derived phosphatidylcholine. Neutral liposome compositions, for example, can be formed from dimyristoyl phosphatidylcholine (DMPC) or dipalmitoyl phosphatidylcholine (DPPC). Anionic liposome compositions generally are formed from dimyristoyl phosphatidylglycerol, while anionic fusogenic liposomes are formed primarily from dioleoyl phosphatidylethanolamine (DOPE). Another type of liposomal composition is formed from phosphatidylcholine (PC) such as, for example, soybean PC, and egg PC. Another type is formed from mixtures of phospholipid and/or phosphatidylcholine and/or cholesterol.

Several studies have assessed the topical delivery of liposomal drug formulations to the skin. Application of liposomes containing interferon to guinea pig skin

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resulted in a reduction of skin herpes sores while delivery of interferon via other means (e.g. as a solution or as an emulsion) were ineffective (Weiner et al., *Journal of Drug Targeting*, 1992, 2, 405-410). Further, an additional study tested the efficacy of interferon administered as part of a liposomal formulation to the administration of interferon using an aqueous system, and concluded that the liposomal formulation was superior to aqueous administration (du Plessis et al., *Antiviral Research*, 1992, 18, 259-265).

Non-ionic liposomal systems have also been examined to determine their utility in the delivery of drugs to the skin, in particular systems comprising non-ionic surfactant and cholesterol. Non-ionic liposomal formulations comprising Novasome™ I (glyceryl dilaurate/cholesterol/polyoxyethylene-10-stearyl ether) and Novasome™ II (glyceryl distearate/cholesterol/polyoxyethylene-10-stearyl ether) were used to deliver cyclosporin-A into the dermis of mouse skin. Results indicated that such non-ionic liposomal systems were effective in facilitating the deposition of cyclosporin-A into different layers of the skin (Hu et al. *S.T.P. Pharma. Sci.*, 1994, 4, 6, 466).

Liposomes also include "sterically stabilized" liposomes, a term which, as used herein, refers to liposomes comprising one or more specialized lipids that, when incorporated into liposomes, result in enhanced circulation lifetimes relative to liposomes lacking such specialized lipids. Examples of sterically stabilized liposomes are those in which part of the vesicle-forming lipid portion of the liposome (A) comprises one or more glycolipids, such as monosialoganglioside GM₁, or (B) is derivatized with one or more hydrophilic polymers, such as

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a polyethylene glycol (PEG) moiety. While not wishing to be bound by any particular theory, it is thought in the art that, at least for sterically stabilized liposomes containing gangliosides, sphingomyelin, or PEG-derivatized lipids, the enhanced circulation half-life of these sterically stabilized liposomes derives from a reduced uptake into cells of the reticuloendothelial system (RES) (Allen et al., *FEBS Letters*, **1987**, 223, 42; Wu et al., *Cancer Research*, **1993**, 53, 3765). Various liposomes comprising one or more glycolipids are known in the art. Papahadjopoulos et al. (*Ann. N.Y. Acad. Sci.*, **1987**, 507, 64) reported the ability of monosialoganglioside G_{M1} , galactocerebroside sulfate and phosphatidylinositol to improve blood half-lives of liposomes. These findings were expounded upon by Gabizon et al. (*Proc. Natl. Acad. Sci. U.S.A.*, **1988**, 85, 6949). U.S. Patent No. 4,837,028 and WO 88/04924, both to Allen et al., disclose liposomes comprising (1) sphingomyelin and (2) the ganglioside G_{M1} or a galactocerebroside sulfate ester. U.S. Patent No. 5,543,152 (Webb et al.) discloses liposomes comprising sphingomyelin. Liposomes comprising 1,2-sn-dimyristoylphosphatidylcholine are disclosed in WO 97/13499 (Lim et al.).

Many liposomes comprising lipids derivatized with one or more hydrophilic polymers, and methods of preparation thereof, are known in the art. Sunamoto et al. (*Bull. Chem. Soc. Jpn.*, **1980**, 53, 2778) described liposomes comprising a nonionic detergent, 2C₁₂15G, that contains a PEG moiety. Illum et al. (*FEBS Lett.*, **1984**, 167, 79) noted that hydrophilic coating of polystyrene particles with polymeric glycols results in significantly enhanced blood half-lives. Synthetic phospholipids modified by the attachment of carboxylic groups of polyalkylene glycols

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(e.g., PEG) are described by Sears (U.S. Patent Nos. 4,426,330 and 4,534,899). Klibanov et al. (*FEBS Lett.*, 1990, 268, 235) described experiments demonstrating that liposomes comprising phosphatidylethanolamine (PE) derivatized with PEG or PEG stearate have significant increases in blood circulation half-lives. Blume et al. (*Biochimica et Biophysica Acta*, 1990, 1029, 91) extended such observations to other PEG-derivatized phospholipids, e.g., DSPE-PEG, formed from the combination of distearoylphosphatidylethanolamine (DSPE) and PEG. Liposomes having covalently bound PEG moieties on their external surface are described in European Patent No. EP 0 445 131 B1 and WO 90/04384 to Fisher. Liposome compositions containing 1-20 mole percent of PE derivatized with PEG, and methods of use thereof, are described by Woodle et al. (U.S. Patent Nos. 5,013,556 and 5,356,633) and Martin et al. (U.S. Patent No. 5,213,804 and European Patent No. EP 0 496 813 B1). Liposomes comprising a number of other lipid-polymer conjugates are disclosed in WO 91/05545 and U.S. Patent No. 5,225,212 (both to Martin et al.) and in WO 94/20073 (Zalipsky et al.) Liposomes comprising PEG-modified ceramide lipids are described in WO 96/10391 (Choi et al.). U.S. Patent Nos. 5,540,935 (Miyazaki et al.) and 5,556,948 (Tagawa et al.) describe PEG-containing liposomes that can be further derivatized with functional moieties on their surfaces.

A limited number of liposomes comprising nucleic acids are known in the art. WO 96/40062 to Thierry et al. discloses methods for encapsulating high molecular weight nucleic acids in liposomes. U.S. Patent No. 5,264,221 to Tagawa et al. discloses protein-bonded liposomes and asserts that the contents of such liposomes may include an antisense RNA. U.S. Patent No. 5,665,710 to Rahman et al.

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describes certain methods of encapsulating oligodeoxynucleotides in liposomes. WO 97/04787 to Love et al. discloses liposomes comprising antisense oligonucleotides targeted to the raf gene.

5 Transfersomes are yet another type of liposomes, and are highly deformable lipid aggregates which are attractive candidates for drug delivery vehicles. Transfersomes may be described as lipid droplets which are so highly deformable that they are easily able to
10 penetrate through pores which are smaller than the droplet. Transfersomes are adaptable to the environment in which they are used, e.g. they are self-optimizing (adaptive to the shape of pores in the skin), self-repairing, frequently reach their targets without
15 fragmenting, and often self-loading. To make transfersomes it is possible to add surface edge-activators, usually surfactants, to a standard liposomal composition. Transfersomes have been used to deliver serum albumin to the skin. The transfersome-mediated
20 delivery of serum albumin has been shown to be as effective as subcutaneous injection of a solution containing serum albumin.

Surfactants find wide application in formulations such as emulsions (including microemulsions) and
25 liposomes. The most common way of classifying and ranking the properties of the many different types of surfactants, both natural and synthetic, is by the use of the hydrophile/lipophile balance (HLB). The nature of the hydrophilic group (also known as the "head") provides the
30 most useful means for categorizing the different surfactants used in formulations (Rieger, in *Pharmaceutical Dosage Forms*, Marcel Dekker, Inc., New York, NY, 1988, p. 285).

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If the surfactant molecule is not ionized, it is classified as a nonionic surfactant. Nonionic surfactants find wide application in pharmaceutical and cosmetic products and are usable over a wide range of pH values.

5 In general their HLB values range from 2 to about 18 depending on their structure. Nonionic surfactants include nonionic esters such as ethylene glycol esters, propylene glycol esters, glyceryl esters, polyglyceryl esters, sorbitan esters, sucrose esters, and ethoxylated
10 esters. Nonionic alkanolamides and ethers such as fatty alcohol ethoxylates, propoxylated alcohols, and ethoxylated/propoxylated block polymers are also included in this class. The polyoxyethylene surfactants are the most popular members of the nonionic surfactant class.

15 If the surfactant molecule carries a negative charge when it is dissolved or dispersed in water, the surfactant is classified as anionic. Anionic surfactants include carboxylates such as soaps, acyl lactylates, acyl amides of amino acids, esters of sulfuric acid such as alkyl
20 sulfates and ethoxylated alkyl sulfates, sulfonates such as alkyl benzene sulfonates, acyl isethionates, acyl taurates and sulfosuccinates, and phosphates. The most important members of the anionic surfactant class are the alkyl sulfates and the soaps.

25 If the surfactant molecule carries a positive charge when it is dissolved or dispersed in water, the surfactant is classified as cationic. Cationic surfactants include quaternary ammonium salts and ethoxylated amines. The quaternary ammonium salts are the most used members of
30 this class.

If the surfactant molecule has the ability to carry either a positive or negative charge, the surfactant is classified as amphoteric. Amphoteric surfactants include

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acrylic acid derivatives, substituted alkylamides, N-alkylbetaines and phosphatides.

The use of surfactants in drug products, formulations and in emulsions has been reviewed (Rieger, in
5 *Pharmaceutical Dosage Forms*, Marcel Dekker, Inc., New York, NY, 1988, p. 285).

Penetration Enhancers

In one embodiment, the present invention employs various penetration enhancers to effect the efficient
10 delivery of nucleic acids, particularly oligonucleotides, to the skin of animals. Most drugs are present in solution in both ionized and nonionized forms. However, usually only lipid soluble or lipophilic drugs readily cross cell membranes. It has been discovered that even
15 non-lipophilic drugs may cross cell membranes if the membrane to be crossed is treated with a penetration enhancer. In addition to aiding the diffusion of non-lipophilic drugs across cell membranes, penetration enhancers also enhance the permeability of lipophilic
20 drugs.

Penetration enhancers may be classified as belonging to one of five broad categories, i.e., surfactants, fatty acids, bile salts, chelating agents, and non-chelating non-surfactants (Lee et al., *Critical Reviews in*
25 *Therapeutic Drug Carrier Systems*, 1991, p.92). Each of the above mentioned classes of penetration enhancers are described below in greater detail.

Surfactants: In connection with the present invention, surfactants (or "surface-active agents") are
30 chemical entities which, when dissolved in an aqueous solution, reduce the surface tension of the solution or the interfacial tension between the aqueous solution and another liquid, with the result that absorption of

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oligonucleotides through the mucosa is enhanced. In addition to bile salts and fatty acids, these penetration enhancers include, for example, sodium lauryl sulfate, polyoxyethylene-9-lauryl ether and polyoxyethylene-20-cetyl ether) (Lee et al., *Critical Reviews in Therapeutic Drug Carrier Systems*, 1991, p.92); and perfluorochemical emulsions, such as FC-43. Takahashi et al., *J. Pharm. Pharmacol.*, 1988, 40, 252).

Fatty acids: Various fatty acids and their derivatives which act as penetration enhancers include, for example, oleic acid, lauric acid, capric acid (n-decanoic acid), myristic acid, palmitic acid, stearic acid, linoleic acid, linolenic acid, dicaprate, tricaprate, monoolein (1-monooleoyl-rac-glycerol), dilaurin, caprylic acid, arachidonic acid, glycerol 1-monocaprate, 1-dodecylazacycloheptan-2-one, acylcarnitines, acylcholines, C₁₋₁₀ alkyl esters thereof (e.g., methyl, isopropyl and t-butyl), and mono- and diglycerides thereof (i.e., oleate, laurate, caprate, myristate, palmitate, stearate, linoleate, etc.) (Lee et al., *Critical Reviews in Therapeutic Drug Carrier Systems*, 1991, p.92; Muranishi, *Critical Reviews in Therapeutic Drug Carrier Systems*, 1990, 7, 1-33; El Hariri et al., *J. Pharm. Pharmacol.*, 1992, 44, 651-654).

Bile salts: The physiological role of bile includes the facilitation of dispersion and absorption of lipids and fat-soluble vitamins (Brunton, Chapter 38 in: Goodman & Gilman's *The Pharmacological Basis of Therapeutics*, 9th Ed., Hardman et al. Eds., McGraw-Hill, New York, 1996, pp. 934-935). Various natural bile salts, and their synthetic derivatives, act as penetration enhancers. Thus the term "bile salts" includes any of the naturally occurring components of bile as well as any of their synthetic

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derivatives. The bile salts of the invention include, for example, cholic acid (or its pharmaceutically acceptable sodium salt, sodium cholate), dehydrocholic acid (sodium dehydrocholate), deoxycholic acid (sodium deoxycholate), glucolic acid (sodium glucolate), glycholic acid (sodium glycocholate), glycodeoxycholic acid (sodium glycodeoxycholate), taurocholic acid (sodium taurocholate), taurodeoxycholic acid (sodium taurodeoxycholate), chenodeoxycholic acid (sodium chenodeoxycholate), ursodeoxycholic acid (UDCA), sodium tauro-24,25-dihydro-fusidate (STDHF), sodium glycodihydrofusidate and polyoxyethylene-9-lauryl ether (POE) (Lee et al., *Critical Reviews in Therapeutic Drug Carrier Systems*, 1991, page 92; Swinyard, Chapter 39 In: *Remington's Pharmaceutical Sciences*, 18th Ed., Gennaro, ed., Mack Publishing Co., Easton, PA, 1990, pages 782-783; Muranishi, *Critical Reviews in Therapeutic Drug Carrier Systems*, 1990, 7, 1-33; Yamamoto et al., *J. Pharm. Exp. Ther.*, 1992, 263, 25; Yamashita et al., *J. Pharm. Sci.*, 1990, 79, 579-583).

Chelating Agents: Chelating agents, as used in connection with the present invention, can be defined as compounds that remove metallic ions from solution by forming complexes therewith, with the result that absorption of oligonucleotides through the mucosa is enhanced. With regards to their use as penetration enhancers in the present invention, chelating agents have the added advantage of also serving as DNase inhibitors, as most characterized DNA nucleases require a divalent metal ion for catalysis and are thus inhibited by chelating agents (Jarrett, *J. Chromatogr.*, 1993, 618, 315-339). Chelating agents of the invention include but are not limited to disodium ethylenediaminetetraacetate

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(EDTA), citric acid, salicylates (e.g., sodium salicylate, 5-methoxysalicylate and homovanilate), *N*-acyl derivatives of collagen, laureth-9 and *N*-amino acyl derivatives of beta-diketones (enamines) (Lee et al., *Critical Reviews in Therapeutic Drug Carrier Systems*, 1991, page 92; Muranishi, *Critical Reviews in Therapeutic Drug Carrier Systems*, 1990, 7, 1-33; Buur et al., *J. Control Rel.*, 1990, 14, 43-51).

Non-chelating non-surfactants: As used herein, non-chelating non-surfactant penetration enhancing compounds can be defined as compounds that demonstrate insignificant activity as chelating agents or as surfactants but that nonetheless enhance absorption of oligonucleotides through the alimentary mucosa (Muranishi, *Critical Reviews in Therapeutic Drug Carrier Systems*, 1990, 7, 1-33). This class of penetration enhancers include, for example, unsaturated cyclic ureas, 1-alkyl- and 1-alkenylazacycloalkanone derivatives (Lee et al., *Critical Reviews in Therapeutic Drug Carrier Systems*, 1991, page 92); and non-steroidal anti-inflammatory agents such as diclofenac sodium, indomethacin and phenylbutazone (Yamashita et al., *J. Pharm. Pharmacol.*, 1987, 39, 621-626).

Agents that enhance uptake of oligonucleotides at the cellular level may also be added to the pharmaceutical and other compositions of the present invention. For example, cationic lipids, such as lipofectin (Junichi et al, U.S. Patent No. 5,705,188), cationic glycerol derivatives, and polycationic molecules, such as polylysine (Lollo et al., PCT Application WO 97/30731), are also known to enhance the cellular uptake of oligonucleotides.

Other agents may be utilized to enhance the penetration of the administered nucleic acids, including glycols such as ethylene glycol and propylene glycol,

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pyrrols such as 2-pyrrol, azones, and terpenes such as limonene and menthone.

Carriers

Certain compositions of the present invention also
5 incorporate carrier compounds in the formulation. As used
herein, "carrier compound" or "carrier" can refer to a
nucleic acid, or analog thereof, which is inert (*i.e.*,
does not possess biological activity *per se*) but is
recognized as a nucleic acid by *in vivo* processes that
10 reduce the bioavailability of a nucleic acid having
biological activity by, for example, degrading the
biologically active nucleic acid or promoting its removal
from circulation. The coadministration of a nucleic acid
and a carrier compound, typically with an excess of the
15 latter substance, can result in a substantial reduction of
the amount of nucleic acid recovered in the liver, kidney
or other extracirculatory reservoirs, presumably due to
competition between the carrier compound and the nucleic
acid for a common receptor. For example, the recovery of
20 a partially phosphorothioate oligonucleotide in hepatic
tissue can be reduced when it is coadministered with
polyinosinic acid, dextran sulfate, polycytidic acid or 4-
acetamido-4'-isothiocyano-stilbene-2,2'-disulfonic acid
(Miyao *et al.*, *Antisense Res. Dev.*, 1995, 5, 115-121;
25 Takakura *et al.*, *Antisense & Nucl. Acid Drug Dev.*, 1996,
6, 177-183).

Excipients

In contrast to a carrier compound, a "pharmaceutical
carrier" or "excipient" is a pharmaceutically acceptable
30 solvent, suspending agent or any other pharmacologically
inert vehicle for delivering one or more nucleic acids to
an animal. The excipient may be liquid or solid and is
selected, with the planned manner of administration in

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mind, so as to provide for the desired bulk, consistency, etc., when combined with a nucleic acid and the other components of a given pharmaceutical composition. Typical pharmaceutical carriers include, but are not limited to, binding agents (e.g., pregelatinized maize starch, polyvinylpyrrolidone or hydroxypropyl methylcellulose, etc.); fillers (e.g., lactose and other sugars, microcrystalline cellulose, pectin, gelatin, calcium sulfate, ethyl cellulose, polyacrylates or calcium hydrogen phosphate, etc.); lubricants (e.g., magnesium stearate, talc, silica, colloidal silicon dioxide, stearic acid, metallic stearates, hydrogenated vegetable oils, corn starch, polyethylene glycols, sodium benzoate, sodium acetate, etc.); disintegrants (e.g., starch, sodium starch glycolate, etc.); and wetting agents (e.g., sodium lauryl sulphate, etc.).

Pharmaceutically acceptable organic or inorganic excipient suitable for non-parenteral administration which do not deleteriously react with nucleic acids can also be used to formulate the compositions of the present invention. Suitable pharmaceutically acceptable carriers include, but are not limited to, water, salt solutions, alcohols, polyethylene glycols, gelatin, lactose, amylose, magnesium stearate, talc, silicic acid, viscous paraffin, hydroxymethylcellulose, polyvinylpyrrolidone and the like.

Formulations for topical administration of nucleic acids may include sterile and non-sterile aqueous solutions, non-aqueous solutions in common solvents such as alcohols, or solutions of the nucleic acids in liquid or solid oil bases. The solutions may also contain buffers, diluents and other suitable additives. Pharmaceutically acceptable organic or inorganic excipients suitable for non-parenteral administration

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which do not deleteriously react with nucleic acids can be used.

Suitable pharmaceutically acceptable excipients include, but are not limited to, water, salt solutions, alcohol, polyethylene glycols, gelatin, lactose, amylose, magnesium stearate, talc, silicic acid, viscous paraffin, hydroxymethylcellulose, polyvinylpyrrolidone and the like.

Other Components

The compositions of the present invention may additionally contain other adjunct components conventionally found in pharmaceutical compositions, at their art-established usage levels. Thus, for example, the compositions may contain additional, compatible, pharmaceutically-active materials such as, for example, antipruritics, astringents, local anesthetics or anti-inflammatory agents, or may contain additional materials useful in physically formulating various dosage forms of the compositions of the present invention, such as dyes, flavoring agents, preservatives, antioxidants, opacifiers, thickening agents and stabilizers. However, such materials, when added, should not unduly interfere with the biological activities of the components of the compositions of the present invention. The formulations can be sterilized and, if desired, mixed with auxiliary agents, e.g., lubricants, preservatives, stabilizers, wetting agents, emulsifiers, salts for influencing osmotic pressure, buffers, colorings, flavorings and/or aromatic substances and the like which do not deleteriously interact with the nucleic acid(s) of the formulation.

Aqueous suspensions may contain substances which increase the viscosity of the suspension including, for example, sodium carboxymethylcellulose, sorbitol and/or dextran. The suspension may also contain stabilizers.

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Certain embodiments of the invention provide pharmaceutical compositions containing (a) one or more antisense compounds and (b) one or more other chemotherapeutic agents which function by a non-antisense mechanism. Examples of such chemotherapeutic agents include but are not limited to daunorubicin, daunomycin, dactinomycin, doxorubicin, epirubicin, idarubicin, esorubicin, bleomycin, mafosfamide, ifosfamide, cytosine arabinoside, bis-chloroethylnitrosurea, busulfan, mitomycin C, actinomycin D, mithramycin, prednisone, hydroxyprogesterone, testosterone, tamoxifen, dacarbazine, procarbazine, hexamethylmelamine, pentamethylmelamine, mitoxantrone, amsacrine, chlorambucil, methylcyclohexylnitrosurea, nitrogen mustards, melphalan, cyclophosphamide, 6-mercaptopurine, 6-thioguanine, cytarabine, 5-azacytidine, hydroxyurea, deoxycoformycin, 4-hydroxyperoxycyclophosphoramidate, 5-fluorouracil (5-FU), 5-fluorodeoxyuridine (5-FUdR), methotrexate (MTX), colchicine, taxol, vincristine, vinblastine, etoposide (VP-16), trimetrexate, irinotecan, topotecan, gemcitabine, teniposide, cisplatin and diethylstilbestrol (DES). See, generally, *The Merck Manual of Diagnosis and Therapy*, 15th Ed. 1987, pp. 1206-1228, Berkow et al., eds., Rahway, N.J. When used with the compounds of the invention, such chemotherapeutic agents may be used individually (e.g., 5-FU and oligonucleotide), sequentially (e.g., 5-FU and oligonucleotide for a period of time followed by MTX and oligonucleotide), or in combination with one or more other such chemotherapeutic agents (e.g., 5-FU, MTX and oligonucleotide, or 5-FU, radiotherapy and oligonucleotide). Anti-inflammatory drugs, including but not limited to nonsteroidal anti-inflammatory drugs and corticosteroids, and antiviral drugs, including but not

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limited to ribivirin, vidarabine, acyclovir and ganciclovir, may also be combined in compositions of the invention. See, generally, *The Merck Manual of Diagnosis and Therapy*, 15th Ed., Berkow et al., eds., 1987, Rahway, N.J., pages 2499-2506 and 46-49, respectively). Other non-antisense chemotherapeutic agents are also within the scope of this invention. Two or more combined compounds may be used together or sequentially.

In another related embodiment, compositions of the invention may contain one or more antisense compounds, particularly oligonucleotides, targeted to a first nucleic acid and one or more additional antisense compounds targeted to a second nucleic acid target. Numerous examples of antisense compounds are known in the art. Two or more combined compounds may be used together or sequentially.

The formulation of therapeutic compositions and their subsequent administration is believed to be within the skill of those in the art. Dosing is dependent on severity and responsiveness of the disease state to be treated, with the course of treatment lasting from several days to several months, or until a cure is effected or a diminution of the disease state is achieved. Optimal dosing schedules can be calculated from measurements of drug accumulation in the body of the patient. Persons of ordinary skill can easily determine optimum dosages, dosing methodologies and repetition rates. Optimum dosages may vary depending on the relative potency of individual oligonucleotides, and can generally be estimated based on EC_{50} s found to be effective in *in vitro* and *in vivo* animal models. In general, dosage is from 0.01 ug to 100 g per kg of body weight, and may be given once or more daily, weekly, monthly or yearly, or even

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once every 2 to 20 years. Persons of ordinary skill in the art can easily estimate repetition rates for dosing based on measured residence times and concentrations of the drug in bodily fluids or tissues. Following
5 successful treatment, it may be desirable to have the patient undergo maintenance therapy to prevent the recurrence of the disease state, wherein the oligonucleotide is administered in maintenance doses, ranging from 0.01 ug to 100 g per kg of body weight, once
10 or more daily, to once every 20 years.

While the present invention has been described with specificity in accordance with certain of its preferred embodiments, the following examples serve only to illustrate the invention and are not intended to limit the
15 same.

EXAMPLES

Example 1

Nucleoside Phosphoramidites for Oligonucleotide Synthesis Deoxy and 2'-alkoxy amidites

20 2'-Deoxy and 2'-methoxy beta-cyanoethyl-diisopropyl phosphoramidites were purchased from commercial sources (e.g. Chemgenes, Needham MA or Glen Research, Inc. Sterling VA). Other 2'-O-alkoxy substituted nucleoside amidites are prepared as described in U.S. Patent
25 5,506,351, herein incorporated by reference. For oligonucleotides synthesized using 2'-alkoxy amidites, the standard cycle for unmodified oligonucleotides was utilized, except the wait step after pulse delivery of tetrazole and base was increased to 360 seconds.

30 Oligonucleotides containing 5-methyl-2'-deoxycytidine (5-Me-C) nucleotides were synthesized according to published methods [Sanghvi, et. al., *Nucleic Acids Research*, 1993, 21, 3197-3203] using commercially

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available phosphoramidites (Glen Research, Sterling VA or ChemGenes, Needham MA).

2'-Fluoro amidites

2'-Fluorodeoxyadenosine amidites

5 2'-fluoro oligonucleotides were synthesized as described previously [Kawasaki, et. al., *J. Med. Chem.*, **1993**, 36, 831-841] and United States patent 5,670,633, herein incorporated by reference. Briefly, the protected nucleoside N6-benzoyl-2'-deoxy-2'-fluoroadenosine was
10 synthesized utilizing commercially available 9-beta-D-arabinofuranosyladenine as starting material and by modifying literature procedures whereby the 2'-alpha-fluoro atom is introduced by a S_N2-displacement of a 2'-beta-trityl group. Thus N6-benzoyl-9-beta-D-
15 arabinofuranosyladenine was selectively protected in moderate yield as the 3',5'-ditetrahydropyranyl (THP) intermediate. Deprotection of the THP and N6-benzoyl groups was accomplished using standard methodologies and standard methods were used to obtain the 5'-
20 dimethoxytrityl- (DMT) and 5'-DMT-3'-phosphoramidite intermediates.

2'-Fluorodeoxyguanosine

The synthesis of 2'-deoxy-2'-fluoroguanosine was accomplished using tetraisopropyldisiloxanyl (TPDS)
25 protected 9-beta-D-arabinofuranosylguanine as starting material, and conversion to the intermediate diisobutyryl-arabinofuranosylguanosine. Deprotection of the TPDS group was followed by protection of the hydroxyl group with THP to give diisobutyryl di-THP protected
30 arabinofuranosylguanine. Selective O-deacylation and triflation was followed by treatment of the crude product with fluoride, then deprotection of the THP groups.

Standard methodologies were used to obtain the 5'-

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DMT- and 5'-DMT-3'-phosphoramidites.

2'-Fluorouridine

Synthesis of 2'-deoxy-2'-fluorouridine was accomplished by the modification of a literature procedure in which 2,2'-anhydro-1-beta-D-arabinofuranosyluracil was treated with 70% hydrogen fluoride-pyridine. Standard procedures were used to obtain the 5'-DMT and 5'-DMT-3'phosphoramidites.

2'-Fluorodeoxycytidine

2'-deoxy-2'-fluorocytidine was synthesized via amination of 2'-deoxy-2'-fluorouridine, followed by selective protection to give N4-benzoyl-2'-deoxy-2'-fluorocytidine. Standard procedures were used to obtain the 5'-DMT and 5'-DMT-3'phosphoramidites.

2'-O-(2-Methoxyethyl) modified amidites

2'-O-Methoxyethyl-substituted nucleoside amidites are prepared as follows, or alternatively, as per the methods of Martin, P., *Helvetica Chimica Acta*, 1995, 78, 486-504.

2,2'-Anhydro[1-(beta-D-arabinofuranosyl)-5-methyluridine]

5-Methyluridine (ribosylthymine, commercially available through Yamasa, Choshi, Japan) (72.0 g, 0.279 M), diphenylcarbonate (90.0 g, 0.420 M) and sodium bicarbonate (2.0 g, 0.024 M) were added to DMF (300 mL). The mixture was heated to reflux, with stirring, allowing the evolved carbon dioxide gas to be released in a controlled manner. After 1 hour, the slightly darkened solution was concentrated under reduced pressure. The resulting syrup was poured into diethylether (2.5 L), with stirring. The product formed a gum. The ether was decanted and the residue was dissolved in a minimum amount of methanol (ca. 400 mL). The solution was poured into fresh ether (2.5 L) to yield a stiff gum. The ether was

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decanted and the gum was dried in a vacuum oven (60°C at 1 mm Hg for 24 h) to give a solid that was crushed to a light tan powder (57 g, 85% crude yield). The NMR spectrum was consistent with the structure, contaminated with phenol as its sodium salt (ca. 5%). The material was used as is for further reactions (or it can be purified further by column chromatography using a gradient of methanol in ethyl acetate (10-25%) to give a white solid, mp 222-4°C).

10 **2'-O-Methoxyethyl-5-methyluridine**

2,2'-Anhydro-5-methyluridine (195 g, 0.81 M), tris(2-methoxyethyl)borate (231 g, 0.98 M) and 2-methoxyethanol (1.2 L) were added to a 2 L stainless steel pressure vessel and placed in a pre-heated oil bath at 160°C. After heating for 48 hours at 155-160°C, the vessel was opened and the solution evaporated to dryness and triturated with MeOH (200 mL). The residue was suspended in hot acetone (1 L). The insoluble salts were filtered, washed with acetone (150 mL) and the filtrate evaporated. The residue (280 g) was dissolved in CH₃CN (600 mL) and evaporated. A silica gel column (3 kg) was packed in CH₂Cl₂/acetone/MeOH (20:5:3) containing 0.5% Et₃NH. The residue was dissolved in CH₂Cl₂ (250 mL) and adsorbed onto silica (150 g) prior to loading onto the column. The product was eluted with the packing solvent to give 160 g (63%) of product. Additional material was obtained by reworking impure fractions.

2'-O-Methoxyethyl-5'-O-dimethoxytrityl-5-methyluridine

30 2'-O-Methoxyethyl-5-methyluridine (160 g, 0.506 M) was co-evaporated with pyridine (250 mL) and the dried residue dissolved in pyridine (1.3 L). A first aliquot of

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dimethoxytrityl chloride (94.3 g, 0.278 M) was added and the mixture stirred at room temperature for one hour. A second aliquot of dimethoxytrityl chloride (94.3 g, 0.278 M) was added and the reaction stirred for an additional
5 one hour. Methanol (170 mL) was then added to stop the reaction. HPLC showed the presence of approximately 70% product. The solvent was evaporated and triturated with CH₃CN (200 mL). The residue was dissolved in CHCl₃ (1.5 L) and extracted with 2x500 mL of saturated NaHCO₃ and 2x500
10 mL of saturated NaCl. The organic phase was dried over Na₂SO₄, filtered and evaporated. 275 g of residue was obtained. The residue was purified on a 3.5 kg silica gel column, packed and eluted with EtOAc/hexane/acetone (5:5:1) containing 0.5% Et₃NH. The pure fractions were
15 evaporated to give 164 g of product. Approximately 20 g additional was obtained from the impure fractions to give a total yield of 183 g (57%).

3'-O-Acetyl-2'-O-methoxyethyl-5'-O-dimethoxytrityl-5-methyluridine

20 2'-O-Methoxyethyl-5'-O-dimethoxytrityl-5-methyluridine (106 g, 0.167 M), DMF/pyridine (750 mL of a 3:1 mixture prepared from 562 mL of DMF and 188 mL of pyridine) and acetic anhydride (24.38 mL, 0.258 M) were combined and stirred at room temperature for 24 hours.
25 The reaction was monitored by TLC by first quenching the TLC sample with the addition of MeOH. Upon completion of the reaction, as judged by TLC, MeOH (50 mL) was added and the mixture evaporated at 35°C. The residue was dissolved in CHCl₃ (800 mL) and extracted with 2x200 mL of saturated
30 sodium bicarbonate and 2x200 mL of saturated NaCl. The water layers were back extracted with 200 mL of CHCl₃. The combined organics were dried with sodium sulfate and evaporated to give 122 g of residue (approx. 90% product).

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The residue was purified on a 3.5 kg silica gel column and eluted using EtOAc/hexane(4:1). Pure product fractions were evaporated to yield 96 g (84%). An additional 1.5 g was recovered from later fractions.

5 **3'-O-Acetyl-2'-O-methoxyethyl-5'-O-dimethoxytrityl-5-methyl-4-triazoleuridine**

A first solution was prepared by dissolving 3'-O-acetyl-2'-O-methoxyethyl-5'-O-dimethoxytrityl-5-methyluridine (96 g, 0.144 M) in CH₃CN (700 mL) and set
10 aside. Triethylamine (189 mL, 1.44 M) was added to a solution of triazole (90 g, 1.3 M) in CH₃CN (1 L), cooled to -5°C and stirred for 0.5 h using an overhead stirrer. POCl₃ was added dropwise, over a 30 minute period, to the stirred solution maintained at 0-10°C, and the resulting
15 mixture stirred for an additional 2 hours. The first solution was added dropwise, over a 45 minute period, to the latter solution. The resulting reaction mixture was stored overnight in a cold room. Salts were filtered from the reaction mixture and the solution was evaporated. The
20 residue was dissolved in EtOAc (1 L) and the insoluble solids were removed by filtration. The filtrate was washed with 1x300 mL of NaHCO₃ and 2x300 mL of saturated NaCl, dried over sodium sulfate and evaporated. The residue was triturated with EtOAc to give the title
25 compound.

2'-O-Methoxyethyl-5'-O-dimethoxytrityl-5-methylcytidine

A solution of 3'-O-acetyl-2'-O-methoxyethyl-5'-O-dimethoxytrityl-5-methyl-4-triazoleuridine (103 g, 0.141
30 M) in dioxane (500 mL) and NH₄OH (30 mL) was stirred at room temperature for 2 hours. The dioxane solution was evaporated and the residue azeotroped with MeOH (2x200 mL). The residue was dissolved in MeOH (300 mL) and

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transferred to a 2 liter stainless steel pressure vessel. MeOH (400 mL) saturated with NH₃ gas was added and the vessel heated to 100°C for 2 hours (TLC showed complete conversion). The vessel contents were evaporated to dryness and the residue was dissolved in EtOAc (500 mL) and washed once with saturated NaCl (200 mL). The organics were dried over sodium sulfate and the solvent was evaporated to give 85 g (95%) of the title compound.

10 **N4-Benzoyl-2'-O-methoxyethyl-5'-O-dimethoxytrityl-5-methylcytidine**

2'-O-Methoxyethyl-5'-O-dimethoxytrityl-5-methylcytidine (85 g, 0.134 M) was dissolved in DMF (800 mL) and benzoic anhydride (37.2 g, 0.165 M) was added with stirring. After stirring for 3 hours, TLC showed the reaction to be approximately 95% complete. The solvent was evaporated and the residue azeotroped with MeOH (200 mL). The residue was dissolved in CHCl₃ (700 mL) and extracted with saturated NaHCO₃ (2x300 mL) and saturated NaCl (2x300 mL), dried over MgSO₄ and evaporated to give a residue (96 g). The residue was chromatographed on a 1.5 kg silica column using EtOAc/hexane (1:1) containing 0.5% Et₃NH as the eluting solvent. The pure product fractions were evaporated to give 90 g (90%) of the title compound.

25 **N4-Benzoyl-2'-O-methoxyethyl-5'-O-dimethoxytrityl-5-methylcytidine-3'-amidite**

N4-Benzoyl-2'-O-methoxyethyl-5'-O-dimethoxytrityl-5-methylcytidine (74 g, 0.10 M) was dissolved in CH₂Cl₂ (1 L). Tetrazole diisopropylamine (7.1 g) and 2-cyanoethoxytetra(isopropyl)phosphite (40.5 mL, 0.123 M) were added with stirring, under a nitrogen atmosphere. The resulting mixture was stirred for 20 hours at room temperature (TLC showed the reaction to be 95% complete). The reaction mixture was extracted with saturated NaHCO₃ (1x300 mL) and

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saturated NaCl (3x300 mL). The aqueous washes were back-extracted with CH₂Cl₂ (300 mL), and the extracts were combined, dried over MgSO₄ and concentrated. The residue obtained was chromatographed on a 1.5 kg silica column using EtOAc/hexane (3:1) as the eluting solvent. The pure fractions were combined to give 90.6 g (87%) of the title compound.

2'-O-(Aminooxyethyl) nucleoside amidites and 2'-O-(dimethylaminooxyethyl) nucleoside amidites

10 **2'-(Dimethylaminooxyethoxy) nucleoside amidites**
 2'-(Dimethylaminooxyethoxy) nucleoside amidites [also known in the art as 2'-O-(dimethylaminooxyethyl) nucleoside amidites] are prepared as described in the following paragraphs. Adenosine, cytidine and guanosine
15 nucleoside amidites are prepared similarly to the thymidine (5-methyluridine) except the exocyclic amines are protected with a benzoyl moiety in the case of adenosine and cytidine and with isobutyryl in the case of guanosine.

20 **5'-O-tert-Butyldiphenylsilyl-O²-2'-anhydro-5-methyluridine**

 O²-2'-anhydro-5-methyluridine (Pro. Bio. Sint., Varese, Italy, 100.0g, 0.416 mmol), dimethylaminopyridine (0.66g, 0.013eq, 0.0054mmol) were dissolved in dry
25 pyridine (500 ml) at ambient temperature under an argon atmosphere and with mechanical stirring. tert-Butyldiphenylchlorosilane (125.8g, 119.0mL, 1.1eq, 0.458mmol) was added in one portion. The reaction was stirred for 16 h at ambient temperature. TLC (R_f 0.22, ethyl acetate) indicated a complete reaction. The
30 solution was concentrated under reduced pressure to a thick oil. This was partitioned between dichloromethane (1 L) and saturated sodium bicarbonate (2x1 L) and brine

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(1 L). The organic layer was dried over sodium sulfate and concentrated under reduced pressure to a thick oil. The oil was dissolved in a 1:1 mixture of ethyl acetate and ethyl ether (600mL) and the solution was cooled to -10°
5 C. The resulting crystalline product was collected by filtration, washed with ethyl ether (3x200 mL) and dried (40°C, 1mm Hg, 24 h) to 149g (74.8%) of white solid. TLC and NMR were consistent with pure product.

10 **5'-O-tert-Butyldiphenylsilyl-2'-O-(2-hydroxyethyl)-5-methyluridine**

In a 2 L stainless steel, unstirred pressure reactor was added borane in tetrahydrofuran (1.0 M, 2.0 eq, 622 mL). In the fume hood and with manual stirring, ethylene glycol (350 mL, excess) was added cautiously at first
15 until the evolution of hydrogen gas subsided. 5'-O-tert-Butyldiphenylsilyl-O²-2'-anhydro-5-methyluridine (149 g, 0.311 mol) and sodium bicarbonate (0.074 g, 0.003 eq) were added with manual stirring. The reactor was sealed and heated in an oil bath until an internal temperature of 160
20 °C was reached and then maintained for 16 h (pressure < 100 psig). The reaction vessel was cooled to ambient and opened. TLC (Rf 0.67 for desired product and Rf 0.82 for ara-T side product, ethyl acetate) indicated about 70% conversion to the product. In order to avoid additional
25 side product formation, the reaction was stopped, concentrated under reduced pressure (10 to 1mm Hg) in a warm water bath (40-100°C) with the more extreme conditions used to remove the ethylene glycol. [Alternatively, once the low boiling solvent is gone, the remaining solution
30 can be partitioned between ethyl acetate and water. The product will be in the organic phase.] The residue was purified by column chromatography (2kg silica gel, ethyl acetate-hexanes gradient 1:1 to 4:1). The appropriate

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fractions were combined, stripped and dried to product as a white crisp foam (84g, 50%), contaminated starting material (17.4g) and pure reusable starting material 20g. The yield based on starting material less pure recovered starting material was 58%. TLC and NMR were consistent with 99% pure product.

2'-O-([2-phthalimidoxy)ethyl]-5'-t-

butyldiphenylsilyl-5-methyluridine

5'-O-tert-Butyldiphenylsilyl-2'-O-(2-hydroxyethyl)-5-methyluridine (20g, 36.98mmol) was mixed with triphenylphosphine (11.63g, 44.36mmol) and N-hydroxyphthalimide (7.24g, 44.36mmol). It was then dried over P₂O₅ under high vacuum for two days at 40°C. The reaction mixture was flushed with argon and dry THF (369.8mL, Aldrich, sure seal bottle) was added to get a clear solution. Diethyl-azodicarboxylate (6.98mL, 44.36mmol) was added dropwise to the reaction mixture. The rate of addition is maintained such that resulting deep red coloration is just discharged before adding the next drop. After the addition was complete, the reaction was stirred for 4 hrs. By that time TLC showed the completion of the reaction (ethylacetate:hexane, 60:40). The solvent was evaporated in vacuum. Residue obtained was placed on a flash column and eluted with ethyl acetate:hexane (60:40), to get 2'-O-([2-phthalimidoxy)ethyl]-5'-t-butyldiphenylsilyl-5-methyluridine as white foam (21.819 g, 86%).

5'-O-tert-butyldiphenylsilyl-2'-O-[(2-formadoximinooxy)ethyl]-5-methyluridine

2'-O-([2-phthalimidoxy)ethyl]-5'-t-butyldiphenylsilyl-5-methyluridine (3.1g, 4.5mmol) was dissolved in dry CH₂Cl₂ (4.5mL) and methylhydrazine (300mL, 4.64mmol) was added dropwise at -10°C to 0°C. After 1 h

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the mixture was filtered, the filtrate was washed with ice cold CH_2Cl_2 and the combined organic phase was washed with water, brine and dried over anhydrous Na_2SO_4 . The solution was concentrated to get 2'-O-(aminooxyethyl) thymidine, which was then dissolved in MeOH (67.5mL). To this formaldehyde (20% aqueous solution, w/w, 1.1 eq.) was added and the resulting mixture was stirred for 1 h. Solvent was removed under vacuum; residue chromatographed to get 5'-O-tert-butyldiphenylsilyl-2'-O-[(2-formadoximinooxy) ethyl]-5-methyluridine as white foam (1.95 g, 78%).

5'-O-tert-Butyldiphenylsilyl-2'-O-[N,N-dimethylaminooxyethyl]-5-methyluridine

5'-O-tert-butyldiphenylsilyl-2'-O-[(2-formadoximinooxy)ethyl]-5-methyluridine (1.77g, 3.12mmol) was dissolved in a solution of 1M pyridinium p-toluenesulfonate (PPTS) in dry MeOH (30.6mL). Sodium cyanoborohydride (0.39g, 6.13mmol) was added to this solution at 10°C under inert atmosphere. The reaction mixture was stirred for 10 minutes at 10°C. After that the reaction vessel was removed from the ice bath and stirred at room temperature for 2 h, the reaction monitored by TLC (5% MeOH in CH_2Cl_2). Aqueous NaHCO_3 solution (5%, 10mL) was added and extracted with ethyl acetate (2x20mL). Ethyl acetate phase was dried over anhydrous Na_2SO_4 , evaporated to dryness. Residue was dissolved in a solution of 1M PPTS in MeOH (30.6mL). Formaldehyde (20% w/w, 30mL, 3.37mmol) was added and the reaction mixture was stirred at room temperature for 10 minutes. Reaction mixture cooled to 10°C in an ice bath, sodium cyanoborohydride (0.39g, 6.13mmol) was added and reaction mixture stirred at 10°C for 10 minutes. After 10 minutes,

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the reaction mixture was removed from the ice bath and stirred at room temperature for 2 hrs. To the reaction mixture 5% NaHCO₃ (25mL) solution was added and extracted with ethyl acetate (2x25mL). Ethyl acetate layer was
5 dried over anhydrous Na₂SO₄ and evaporated to dryness. The residue obtained was purified by flash column chromatography and eluted with 5% MeOH in CH₂Cl₂ to get 5'-O-tert-butylldiphenylsilyl-2'-O-[N,N-dimethylaminooxyethyl]-5-methyluridine as a white foam
10 (14.6g, 80%).

2'-O-(dimethylaminoxyethyl)-5-methyluridine

Triethylamine trihydrofluoride (3.91mL, 24.0mmol) was dissolved in dry THF and triethylamine (1.67mL, 12mmol, dry, kept over KOH). This mixture of triethylamine-2HF
15 was then added to 5'-O-tert-butylldiphenylsilyl-2'-O-[N,N-dimethylaminoxyethyl]-5-methyluridine (1.40g, 2.4mmol) and stirred at room temperature for 24 hrs. Reaction was monitored by TLC (5% MeOH in CH₂Cl₂). Solvent was removed under vacuum and the residue placed on a flash column and
20 eluted with 10% MeOH in CH₂Cl₂ to get 2'-O-(dimethylaminoxyethyl)-5-methyluridine (766mg, 92.5%).

5'-O-DMT-2'-O-(dimethylaminoxyethyl)-5-methyluridine

2'-O-(dimethylaminoxyethyl)-5-methyluridine (750mg, 2.17mmol) was dried over P₂O₅ under high vacuum overnight
25 at 40°C. It was then co-evaporated with anhydrous pyridine (20mL). The residue obtained was dissolved in pyridine (11mL) under argon atmosphere. 4-dimethylaminopyridine (26.5mg, 2.60mmol), 4,4'-dimethoxytrityl chloride (880mg, 2.60mmol) was added to the mixture and the reaction
30 mixture was stirred at room temperature until all of the starting material disappeared. Pyridine was removed under vacuum and the residue chromatographed and eluted with 10% MeOH in CH₂Cl₂ (containing a few drops of pyridine) to get

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5'-O-DMT-2'-O-(dimethylamino-oxyethyl)-5-methyluridine
(1.13g, 80%).

5'-O-DMT-2'-O-(2-N,N-dimethylaminooxyethyl)-5-
methyluridine-3'-[(2-cyanoethyl)-N,N-
5 diisopropylphosphoramidite]

5'-O-DMT-2'-O-(dimethylaminooxyethyl)-5-methyluridine
(1.08g, 1.67mmol) was co-evaporated with toluene (20mL).
To the residue N,N-diisopropylamine tetrazonide (0.29g,
1.67mmol) was added and dried over P₂O₅ under high vacuum
10 overnight at 40°C. Then the reaction mixture was dissolved
in anhydrous acetonitrile (8.4mL) and 2-cyanoethyl-
N,N,N¹,N¹-tetraisopropylphosphoramidite (2.12mL, 6.08mmol)
was added. The reaction mixture was stirred at ambient
temperature for 4 hrs under inert atmosphere. The
15 progress of the reaction was monitored by TLC
(hexane:ethyl acetate 1:1). The solvent was evaporated,
then the residue was dissolved in ethyl acetate (70mL) and
washed with 5% aqueous NaHCO₃ (40mL). Ethyl acetate layer
was dried over anhydrous Na₂SO₄ and concentrated. Residue
20 obtained was chromatographed (ethyl acetate as eluent) to
get 5'-O-DMT-2'-O-(2-N,N-dimethylaminooxyethyl)-5-
methyluridine-3'-[(2-cyanoethyl)-N,N-
diisopropylphosphoramidite] as a foam (1.04g, 74.9%).

2'-(Aminooxyethoxy) nucleoside amidites

25 2'-(Aminooxyethoxy) nucleoside amidites [also known
in the art as 2'-O-(aminooxyethyl) nucleoside amidites]
are prepared as described in the following paragraphs.
Adenosine, cytidine and thymidine nucleoside amidites are
prepared similarly.

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N2-isobutyryl-6-O-diphenylcarbamoyl-2'-O-(2-ethylacetyl)-5'-O-(4,4'-dimethoxytrityl)guanosine-3'-[(2-cyanoethyl)-N,N-diisopropylphosphoramidite]

The 2'-O-aminoxyethyl guanosine analog may be
5 obtained by selective 2'-O-alkylation of diaminopurine
riboside. Multigram quantities of diaminopurine riboside
may be purchased from Schering AG (Berlin) to provide 2'-
O-(2-ethylacetyl) diaminopurine riboside along with a
minor amount of the 3'-O-isomer. 2'-O-(2-ethylacetyl)
10 diaminopurine riboside may be resolved and converted to
2'-O-(2-ethylacetyl)guanosine by treatment with adenosine
deaminase. (McGee, D. P. C., Cook, P. D., Guinosso, C. J.,
WO 94/02501 A1 940203.) Standard protection procedures
should afford 2'-O-(2-ethylacetyl)-5'-O-(4,4'-
15 dimethoxytrityl)guanosine and 2-N-isobutyryl-6-O-
diphenylcarbamoyl-2'-O-(2-ethylacetyl)-5'-O-(4,4'-
dimethoxytrityl)guanosine which may be reduced to provide
2-N-isobutyryl-6-O-diphenylcarbamoyl-2'-O-(2-
hydroxyethyl)-5'-O-(4,4'-dimethoxytrityl)guanosine. As
20 before the hydroxyl group may be displaced by N-
hydroxyphthalimide via a Mitsunobu reaction, and the
protected nucleoside may phosphitylated as usual to yield
2-N-isobutyryl-6-O-diphenylcarbamoyl-2'-O-([2-
phthalmidoxy]ethyl)-5'-O-(4,4'-dimethoxytrityl)guanosine-
25 3'-[(2-cyanoethyl)-N,N-diisopropylphosphoramidite].
**2'-dimethylaminoethoxyethoxy (2'-DMAEOE) nucleoside
amidites**

. 2'-dimethylaminoethoxyethoxy nucleoside amidites
(also known in the art as 2'-O-dimethylaminoethoxyethyl,
30 i.e., 2'-O-CH₂-O-CH₂-N(CH₂)₂, or 2'-DMAEOE nucleoside
amidites) are prepared as follows. Other nucleoside
amidites are prepared similarly.

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2'-O-[2(2-N,N-dimethylaminoethoxy)ethyl]-5-methyl uridine

2 [2- (Dimethylamino)ethoxy]ethanol (Aldrich, 6.66 g, 50 mmol) is slowly added to a solution of borane in tetrahydrofuran (1 M, 10 mL, 10 mmol) with stirring in a 100 mL bomb. Hydrogen gas evolves as the solid dissolves. O²-, 2'-anhydro-5-methyluridine (1.2 g, 5 mmol), and sodium bicarbonate (2.5 mg) are added and the bomb is sealed, placed in an oil bath and heated to 155°C for 26 hours. The bomb is cooled to room temperature and opened. The crude solution is concentrated and the residue partitioned between water (200 mL) and hexanes (200 mL). The excess phenol is extracted into the hexane layer. The aqueous layer is extracted with ethyl acetate (3x200 mL) and the combined organic layers are washed once with water, dried over anhydrous sodium sulfate and concentrated. The residue is columned on silica gel using methanol/methylene chloride 1:20 (which has 2% triethylamine) as the eluent. As the column fractions are concentrated a colorless solid forms which is collected to give the title compound as a white solid.

5'-O-dimethoxytrityl-2'-O-[2(2-N,N-dimethylaminoethoxy)ethyl]-5-methyl uridine

To 0.5 g (1.3 mmol) of 2'-O-[2(2-N,N-dimethylaminoethoxy)ethyl]-5-methyl uridine in anhydrous pyridine (8 mL), triethylamine (0.36 mL) and dimethoxytrityl chloride (DMT-Cl, 0.87 g, 2 eq.) are added and stirred for 1 hour. The reaction mixture is poured into water (200 mL) and extracted with CH₂Cl₂ (2x200 mL). The combined CH₂Cl₂ layers are washed with saturated NaHCO₃ solution, followed by saturated NaCl solution and dried over anhydrous sodium sulfate. Evaporation of the solvent followed by silica gel chromatography using MeOH:CH₂Cl₂:Et₃N (20:1, v/v, with 1% triethylamine) gives the title compound.

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5'-O-Dimethoxytrityl-2'-O-[2(2-N,N-dimethylaminoethoxy)ethyl]]-5-methyl uridine-3'-O-(cyanoethyl-N,N-diisopropyl)phosphoramidite

5 Diisopropylaminotetrazolide (0.6 g) and 2-cyanoethoxy-N,N-diisopropyl phosphoramidite (1.1 mL, 2 eq.) are added to a solution of 5'-O-dimethoxytrityl-2'-O-[2(2-N,N-dimethylaminoethoxy)ethyl]]-5-methyluridine (2.17 g, 3 mmol) dissolved in CH₂Cl₂ (20 mL) under an atmosphere of argon. The reaction mixture is stirred overnight and the solvent evaporated. The resulting residue is purified by silica gel flash column chromatography with ethyl acetate as the eluent to give the title compound.

Example 2

15 Oligonucleotide synthesis

Unsubstituted and substituted phosphodiester (P=O) oligonucleotides are synthesized on an automated DNA synthesizer (Applied Biosystems model 380B) using standard phosphoramidite chemistry with oxidation by iodine.

20 Phosphorothioates (P=S) are synthesized as for the phosphodiester oligonucleotides except the standard oxidation bottle was replaced by 0.2 M solution of 3H-1,2-benzodithiole-3-one 1,1-dioxide in acetonitrile for the stepwise thiation of the phosphite linkages. The thiation wait step was increased to 68 sec and was followed by the capping step. After cleavage from the CPG column and deblocking in concentrated ammonium hydroxide at 55°C (18 h), the oligonucleotides were purified by precipitating twice with 2.5 volumes of ethanol from a 0.5 M NaCl solution. Phosphinate oligonucleotides are prepared as described in U.S. Patent 5,508,270, herein incorporated by reference.

Alkyl phosphonate oligonucleotides are prepared as

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described in U.S. Patent 4,469,863, herein incorporated by reference.

3'-Deoxy-3'-methylene phosphonate oligonucleotides are prepared as described in U.S. Patents 5,610,289 or
5 5,625,050, herein incorporated by reference.

Phosphoramidite oligonucleotides are prepared as described in U.S. Patent, 5,256,775 or U.S. Patent 5,366,878, herein incorporated by reference.

Alkylphosphonothioate oligonucleotides are prepared
10 as described in published PCT applications PCT/US94/00902 and PCT/US93/06976 (published as WO 94/17093 and WO 94/02499, respectively), herein incorporated by reference.

3'-Deoxy-3'-amino phosphoramidate oligonucleotides are prepared as described in U.S. Patent 5,476,925, herein
15 incorporated by reference.

Phosphotriester oligonucleotides are prepared as described in U.S. Patent 5,023,243, herein incorporated by reference.

Borano phosphate oligonucleotides are prepared as
20 described in U.S. Patents 5,130,302 and 5,177,198, both herein incorporated by reference.

Example 3

Oligonucleoside Synthesis

Methylenemethylimino linked oligonucleosides, also
25 identified as MMI linked oligonucleosides, methylenedi-methylhydrazo linked oligonucleosides, also identified as MDH linked oligonucleosides, and methylenecarbonylamino linked oligonucleosides, also identified as amide-3 linked oligonucleosides, and methyleneaminocarbonyl linked oligo-
30 nucleosides, also identified as amide-4 linked oligonucleosides, as well as mixed backbone compounds having, for instance, alternating MMI and P=O or P=S linkages are prepared as described in U.S. Patents 5,378,825,

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5,386,023, 5,489,677, 5,602,240 and 5,610,289, all of which are herein incorporated by reference.

Formacetal and thioformacetal linked oligonucleosides are prepared as described in U.S. Patents 5,264,562 and 5,264,564, herein incorporated by reference.

Ethylene oxide linked oligonucleosides are prepared as described in U.S. Patent 5,223,618, herein incorporated by reference.

Example 4

10 PNA Synthesis

Peptide nucleic acids (PNAs) are prepared in accordance with any of the various procedures referred to in *Peptide Nucleic Acids (PNA): Synthesis, Properties and Potential Applications, Bioorganic & Medicinal Chemistry*, 15 1996, 4, 5-23. They may also be prepared in accordance with U.S. Patents 5,539,082, 5,700,922, and 5,719,262, herein incorporated by reference.

Example 5

Synthesis of Chimeric Oligonucleotides

20 Chimeric oligonucleotides, oligonucleosides or mixed oligonucleotides/oligonucleosides of the invention can be of several different types. These include a first type wherein the "gap" segment of linked nucleosides is positioned between 5' and 3' "wing" segments of linked 25 nucleosides and a second "open end" type wherein the "gap" segment is located at either the 3' or the 5' terminus of the oligomeric compound. Oligonucleotides of the first type are also known in the art as "gapmers" or gapped oligonucleotides. Oligonucleotides of the second type are 30 also known in the art as "hemimers" or "wingmers".

[2'-O-Me] -- [2'-deoxy] -- [2'-O-Me] Chimeric

Phosphorothioate Oligonucleotides

Chimeric oligonucleotides having 2'-O-alkyl

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phosphorothioate and 2'-deoxy phosphorothioate oligonucleotide segments are synthesized using an Applied Biosystems automated DNA synthesizer Model 380B, as above. Oligonucleotides are synthesized using the automated synthesizer and 2'-deoxy-5'-dimethoxytrityl-3'-O-phosphoramidite for the DNA portion and 5'-dimethoxytrityl-2'-O-methyl-3'-O-phosphoramidite for 5' and 3' wings. The standard synthesis cycle is modified by increasing the wait step after the delivery of tetrazole and base to 600 s repeated four times for RNA and twice for 2'-O-methyl. The fully protected oligonucleotide is cleaved from the support and the phosphate group is deprotected in 3:1 ammonia/ethanol at room temperature overnight then lyophilized to dryness. Treatment in methanolic ammonia for 24 hrs at room temperature is then done to deprotect all bases and sample was again lyophilized to dryness. The pellet is resuspended in 1M TBAF in THF for 24 hrs at room temperature to deprotect the 2' positions. The reaction is then quenched with 1M TEAA and the sample is then reduced to 1/2 volume by rotovac before being desalted on a G25 size exclusion column. The oligo recovered is then analyzed spectrophotometrically for yield and for purity by capillary electrophoresis and by mass spectrometry.

25 [2'-O-(2-Methoxyethyl)]--[2'-deoxy]--[2'-O-(Methoxyethyl)] Chimeric Phosphorothioate Oligonucleotides

30 [2'-O-(2-methoxyethyl)]--[2'-deoxy]--[2'-O-(methoxyethyl)] chimeric phosphorothioate oligonucleotides were prepared as per the procedure above for the 2'-O-methyl chimeric oligonucleotide, with the substitution of 2'-O-(methoxyethyl) amidites for the 2'-O-methyl amidites.

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[2'-O-(2-Methoxyethyl)Phosphodiester] -- [2'-deoxy
Phosphorothioate] -- [2'-O-(2-Methoxyethyl)
Phosphodiester] Chimeric Oligonucleotides

[2'-O-(2-methoxyethyl phosphodiester] -- [2'-deoxy
5 phosphorothioate] -- [2'-O-(methoxyethyl) phosphodiester]
chimeric oligonucleotides are prepared as per the above
procedure for the 2'-O-methyl chimeric oligonucleotide
with the substitution of 2'-O-(methoxyethyl) amidites for
the 2'-O-methyl amidites, oxidization with iodine to
10 generate the phosphodiester internucleotide linkages
within the wing portions of the chimeric structures and
sulfurization utilizing 3,4-dihydro-2H-benzodithiole-3-one 1,1
dioxide (Beaucage Reagent) to generate the
phosphorothioate internucleotide linkages for the center
15 gap.

Other chimeric oligonucleotides, chimeric oligo-
nucleosides and mixed chimeric oligonucleotides/oligo-
nucleosides are synthesized according to United States
patent 5,623,065, herein incorporated by reference.

20 **Example 6**

Oligonucleotide Isolation

After cleavage from the controlled pore glass column
(Applied Biosystems) and deblocking in concentrated
ammonium hydroxide at 55°C for 18 hours, the
25 oligonucleotides or oligonucleosides are purified by
precipitation twice out of 0.5 M NaCl with 2.5 volumes
ethanol. Synthesized oligonucleotides were analyzed by
polyacrylamide gel electrophoresis on denaturing gels and
judged to be at least 85% full length material. The
30 relative amounts of phosphorothioate and phosphodiester
linkages obtained in synthesis were periodically checked
by ³¹P nuclear magnetic resonance spectroscopy, and for
some studies oligonucleotides were purified by HPLC, as

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described by Chiang et al., *J. Biol. Chem.* **1991**, *266*, 18162-18171. Results obtained with HPLC-purified material were similar to those obtained with non-HPLC purified material.

5 **Example 7**

Oligonucleotide Synthesis - 96 Well Plate Format

Oligonucleotides were synthesized via solid phase P(III) phosphoramidite chemistry on an automated synthesizer capable of assembling 96 sequences simultaneously in a standard 96 well format. Phosphodiester internucleotide linkages were afforded by oxidation with aqueous iodine. Phosphorothioate internucleotide linkages were generated by sulfurization utilizing 3,4-dihydro-2H-benzothio-3-one 1,1-dioxide (Beaucage Reagent) in anhydrous acetonitrile. Standard base-protected beta-cyanoethyl-diisopropyl phosphoramidites were purchased from commercial vendors (e.g. PE-Applied Biosystems, Foster City, CA, or Pharmacia, Piscataway, NJ). Non-standard nucleosides are synthesized as per known literature or patented methods. They are utilized as base protected beta-cyanoethyl-diisopropyl phosphoramidites.

Oligonucleotides were cleaved from support and deprotected with concentrated NH_4OH at elevated temperature (55-60°C) for 12-16 hours and the released product then dried in vacuo. The dried product was then re-suspended in sterile water to afford a master plate from which all analytical and test plate samples are then diluted utilizing robotic pipettors.

30 **Example 8**

Oligonucleotide Analysis - 96 Well Plate Format

The concentration of oligonucleotide in each well was assessed by dilution of samples and UV absorption

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spectroscopy. The full-length integrity of the individual products was evaluated by capillary electrophoresis (CE) in either the 96 well format (Beckman P/ACE™ MDQ) or, for individually prepared samples, on a commercial CE apparatus (e.g., Beckman P/ACE™ 5000, ABI 270). Base and backbone composition was confirmed by mass analysis of the compounds utilizing electrospray-mass spectroscopy. All assay test plates were diluted from the master plate using single and multi-channel robotic pipettors. Plates were judged to be acceptable if at least 85% of the compounds on the plate were at least 85% full length.

Example 9

Cell culture and oligonucleotide treatment

The effect of antisense compounds on target nucleic acid expression can be tested in any of a variety of cell types provided that the target nucleic acid is present at measurable levels. This can be routinely determined using, for example, PCR or Northern blot analysis. The following 7 cell types are provided for illustrative purposes, but other cell types can be routinely used, provided that the target is expressed in the cell type chosen. This can be readily determined by methods routine in the art, for example Northern blot analysis, Ribonuclease protection assays, or RT-PCR.

25 T-24 cells:

The human transitional cell bladder carcinoma cell line T-24 was obtained from the American Type Culture Collection (ATCC) (Manassas, VA). T-24 cells were routinely cultured in complete McCoy's 5A basal media (Gibco/Life Technologies, Gaithersburg, MD) supplemented with 10% fetal calf serum (Gibco/Life Technologies, Gaithersburg, MD), penicillin 100 units per mL, and streptomycin 100 micrograms per mL (Gibco/Life

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Technologies, Gaithersburg, MD). Cells were routinely passaged by trypsinization and dilution when they reached 90% confluence. Cells were seeded into 96-well plates (Falcon-Primaria #3872) at a density of 7000 cells/well for use in RT-PCR analysis.

For Northern blotting or other analysis, cells may be seeded onto 100 mm or other standard tissue culture plates and treated similarly, using appropriate volumes of medium and oligonucleotide.

10 A549 cells:

The human lung carcinoma cell line A549 was obtained from the American Type Culture Collection (ATCC) (Manassas, VA). A549 cells were routinely cultured in DMEM basal media (Gibco/Life Technologies, Gaithersburg, MD) supplemented with 10% fetal calf serum (Gibco/Life Technologies, Gaithersburg, MD), penicillin 100 units per mL, and streptomycin 100 micrograms per mL (Gibco/Life Technologies, Gaithersburg, MD). Cells were routinely passaged by trypsinization and dilution when they reached 90% confluence.

NHDF cells:

Human neonatal dermal fibroblast (NHDF) were obtained from the Clonetics Corporation (Walkersville MD). NHDFs were routinely maintained in Fibroblast Growth Medium (Clonetics Corporation, Walkersville MD) supplemented as recommended by the supplier. Cells were maintained for up to 10 passages as recommended by the supplier.

HEK cells:

Human embryonic keratinocytes (HEK) were obtained from the Clonetics Corporation (Walkersville MD). HEKs were routinely maintained in Keratinocyte Growth Medium (Clonetics Corporation, Walkersville MD) formulated as recommended by the supplier. Cells were routinely

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maintained for up to 10 passages as recommended by the supplier.

HepG2 cells:

The human hepatoblastoma cell line HepG2 was obtained from the American Type Culture Collection (Manassas, VA). HepG2 cells were routinely cultured in Eagle's MEM supplemented with 10% fetal calf serum, non-essential amino acids, and 1 mM sodium pyruvate (Gibco/Life Technologies, Gaithersburg, MD). Cells were routinely passaged by trypsinization and dilution when they reached 90% confluence. Cells were seeded into 96-well plates (Falcon-Primaria #3872) at a density of 7000 cells/well for use in RT-PCR analysis.

For Northern blotting or other analyses, cells may be seeded onto 100 mm or other standard tissue culture plates and treated similarly, using appropriate volumes of medium and oligonucleotide.

AML12 cells:

The AML12 (alpha mouse liver 12) cell line was established from hepatocytes from a mouse (CD1 strain, line MT42) transgenic for human TGF alpha. Cells are cultured in a 1:1 mixture of Dulbecco's modified Eagle's medium and Ham's F12 medium with 0.005 mg/ml insulin, 0.005 mg/ml transferrin, 5 ng/ml selenium, and 40 ng/ml dexamethasone, and 90%; 10% fetal bovine serum. For subculturing, spent medium is removed and fresh media of 0.25% trypsin, 0.03% EDTA solution is added. Fresh trypsin solution (1 to 2 ml) is added and the culture is left to sit at room temperature until the cells detach.

Cells were routinely passaged by trypsinization and dilution when they reached 90% confluence. Cells were seeded into 96-well plates (Falcon-Primaria #3872) at a density of 7000 cells/well for use in RT-PCR analysis.

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For Northern blotting or other analyses, cells may be seeded onto 100 mm or other standard tissue culture plates and treated similarly, using appropriate volumes of medium and oligonucleotide.

5 Primary mouse hepatocytes:

Primary mouse hepatocytes were prepared from CD-1 mice purchased from Charles River Labs (Wilmington, MA) and were routinely cultured in Hepatocyte Attachment Media (Gibco) supplemented with 10% Fetal Bovine Serum (Gibco/Life Technologies, Gaithersburg, MD), 250nM dexamethasone (Sigma), and 10nM bovine insulin (Sigma). Cells were seeded into 96-well plates (Falcon-Primaria #3872) at a density of 10000 cells/well for use in RT-PCR analysis.

15 For Northern blotting or other analyses, cells are plated onto 100 mm or other standard tissue culture plates coated with rat tail collagen (200ug/mL) (Becton Dickinson) and treated similarly using appropriate volumes of medium and oligonucleotide.

20 Treatment with antisense compounds:

When cells reached 80% confluency, they were treated with oligonucleotide. For cells grown in 96-well plates, wells were washed once with 200 μ L OPTI-MEMTM-1 reduced-serum medium (Gibco BRL) and then treated with 130 μ L of OPTI-MEMTM-1 containing 3.75 μ g/mL LIPOFECTINTM (Gibco BRL) and the desired concentration of oligonucleotide. After 4-7 hours of treatment, the medium was replaced with fresh medium. Cells were harvested 16-24 hours after oligonucleotide treatment.

30 The concentration of oligonucleotide used varies from cell line to cell line. To determine the optimal oligonucleotide concentration for a particular cell line, the cells are treated with a positive control

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oligonucleotide at a range of concentrations. For human cells the positive control oligonucleotide is ISIS 13920, **TCCGTCATCGCTCCTCAGGG**, SEQ ID NO: 1, a 2'-O-methoxyethyl gapmer (2'-O-methoxyethyls shown in bold) with a phosphorothioate backbone which is targeted to human H-ras. For mouse or rat cells the positive control oligonucleotide is ISIS 15770, **ATGCATTCTGCCCCCAAGGA**, SEQ ID NO: 2, a 2'-O-methoxyethyl gapmer (2'-O-methoxyethyls shown in bold) with a phosphorothioate backbone which is targeted to both mouse and rat c-raf. The concentration of positive control oligonucleotide that results in 80% inhibition of c-Ha-ras (for ISIS 13920) or c-raf (for ISIS 15770) mRNA is then utilized as the screening concentration for new oligonucleotides in subsequent experiments for that cell line. If 80% inhibition is not achieved, the lowest concentration of positive control oligonucleotide that results in 60% inhibition of H-ras or c-raf mRNA is then utilized as the oligonucleotide screening concentration in subsequent experiments for that cell line. If 60% inhibition is not achieved, that particular cell line is deemed as unsuitable for oligonucleotide transfection experiments.

Example 10

Analysis of oligonucleotide inhibition of apolipoprotein B expression

Antisense modulation of apolipoprotein B expression can be assayed in a variety of ways known in the art. For example, apolipoprotein B mRNA levels can be quantitated by, e.g., Northern blot analysis, competitive polymerase chain reaction (PCR), or real-time PCR (RT-PCR). Real-time quantitative PCR is presently preferred. RNA analysis can be performed on total cellular RNA or poly(A)+ mRNA. Methods of RNA isolation are taught in,

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for example, Ausubel, F.M. et al., *Current Protocols in Molecular Biology*, Volume 1, pp. 4.1.1-4.2.9 and 4.5.1-4.5.3, John Wiley & Sons, Inc., 1993. Northern blot analysis is routine in the art and is taught in, for example, Ausubel, F.M. et al., *Current Protocols in Molecular Biology*, Volume 1, pp. 4.2.1-4.2.9, John Wiley & Sons, Inc., 1996. Real-time quantitative (PCR) can be conveniently accomplished using the commercially available ABI PRISM™ 7700 Sequence Detection System, available from PE-Applied Biosystems, Foster City, CA and used according to manufacturer's instructions.

Protein levels of apolipoprotein B can be quantitated in a variety of ways well known in the art, such as immunoprecipitation, Western blot analysis (immunoblotting), ELISA or fluorescence-activated cell sorting (FACS). Antibodies directed to apolipoprotein B can be identified and obtained from a variety of sources, such as the MSRS catalog of antibodies (Aerie Corporation, Birmingham, MI), or can be prepared via conventional antibody generation methods. Methods for preparation of polyclonal antisera are taught in, for example, Ausubel, F.M. et al., *Current Protocols in Molecular Biology*, Volume 2, pp. 11.12.1-11.12.9, John Wiley & Sons, Inc., 1997. Preparation of monoclonal antibodies is taught in, for example, Ausubel, F.M. et al., *Current Protocols in Molecular Biology*, Volume 2, pp. 11.4.1-11.11.5, John Wiley & Sons, Inc., 1997.

Immunoprecipitation methods are standard in the art and can be found at, for example, Ausubel, F.M. et al., *Current Protocols in Molecular Biology*, Volume 2, pp. 10.16.1-10.16.11, John Wiley & Sons, Inc., 1998. Western blot (immunoblot) analysis is standard in the art and can be found at, for example, Ausubel, F.M. et al., *Current*

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Protocols in Molecular Biology, Volume 2, pp. 10.8.1-10.8.21, John Wiley & Sons, Inc., 1997. Enzyme-linked immunosorbent assays (ELISA) are standard in the art and can be found at, for example, Ausubel, F.M. et al.,
5 *Current Protocols in Molecular Biology*, Volume 2, pp. 11.2.1-11.2.22, John Wiley & Sons, Inc., 1991.

Example 11**Poly(A)+ mRNA isolation**

Poly(A)+ mRNA was isolated according to Miura et al.,
10 *Clin. Chem.*, 1996, 42, 1758-1764. Other methods for poly(A)+ mRNA isolation are taught in, for example, Ausubel, F.M. et al., *Current Protocols in Molecular Biology*, Volume 1, pp. 4.5.1-4.5.3, John Wiley & Sons, Inc., 1993. Briefly, for cells grown on 96-well plates,
15 growth medium was removed from the cells and each well was washed with 200 μ L cold PBS. 60 μ L lysis buffer (10 mM Tris-HCl, pH 7.6, 1 mM EDTA, 0.5 M NaCl, 0.5% NP-40, 20 mM vanadyl-ribonucleoside complex) was added to each well, the plate was gently agitated and then incubated at room
20 temperature for five minutes. 55 μ L of lysate was transferred to Oligo d(T) coated 96-well plates (AGCT Inc., Irvine CA). Plates were incubated for 60 minutes at room temperature, washed 3 times with 200 μ L of wash buffer (10 mM Tris-HCl pH 7.6, 1 mM EDTA, 0.3 M NaCl).
25 After the final wash, the plate was blotted on paper towels to remove excess wash buffer and then air-dried for 5 minutes. 60 μ L of elution buffer (5 mM Tris-HCl pH 7.6), preheated to 70°C was added to each well, the plate was incubated on a 90°C hot plate for 5 minutes, and the eluate
30 was then transferred to a fresh 96-well plate.

Cells grown on 100 mm or other standard plates may be

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treated similarly, using appropriate volumes of all solutions.

Example 12**Total RNA Isolation**

5 Total RNA was isolated using an RNEASY 96™ kit and buffers purchased from Qiagen Inc. (Valencia CA) following the manufacturer's recommended procedures. Briefly, for cells grown on 96-well plates, growth medium was removed from the cells and each well was washed with 200 µL cold
10 PBS. 100 µL Buffer RLT was added to each well and the plate vigorously agitated for 20 seconds. 100 µL of 70% ethanol was then added to each well and the contents mixed by pipetting three times up and down. The samples were then transferred to the RNEASY 96™ well plate attached to
15 a QIAVAC™ manifold fitted with a waste collection tray and attached to a vacuum source. Vacuum was applied for 15 seconds. 1 mL of Buffer RW1 was added to each well of the RNEASY 96™ plate and the vacuum again applied for 15 seconds. 1 mL of Buffer RPE was then added to each well
20 of the RNEASY 96™ plate and the vacuum applied for a period of 15 seconds. The Buffer RPE wash was then repeated and the vacuum was applied for an additional 10 minutes. The plate was then removed from the QIAVAC™ manifold and blotted dry on paper towels. The plate was
25 then re-attached to the QIAVAC™ manifold fitted with a collection tube rack containing 1.2 mL collection tubes. RNA was then eluted by pipetting 60 µL water into each well, incubating 1 minute, and then applying the vacuum for 30 seconds. The elution step was repeated with an
30 additional 60 µL water.

The repetitive pipetting and elution steps may be

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automated using a QIAGEN Bio-Robot 9604 (Qiagen, Inc., Valencia CA). Essentially, after lysing of the cells on the culture plate, the plate is transferred to the robot deck where the pipetting, DNase treatment and elution steps are carried out.

Example 13

Real-time Quantitative PCR Analysis of apolipoprotein B mRNA Levels

Quantitation of apolipoprotein B mRNA levels was determined by real-time quantitative PCR using the ABI PRISM™ 7700 Sequence Detection System (PE-Applied Biosystems, Foster City, CA) according to manufacturer's instructions. This is a closed-tube, non-gel-based, fluorescence detection system which allows high-throughput quantitation of polymerase chain reaction (PCR) products in real-time. As opposed to standard PCR, in which amplification products are quantitated after the PCR is completed, products in real-time quantitative PCR are quantitated as they accumulate. This is accomplished by including in the PCR reaction an oligonucleotide probe that anneals specifically between the forward and reverse PCR primers, and contains two fluorescent dyes. A reporter dye (e.g., JOE, FAM, or VIC, obtained from either Operon Technologies Inc., Alameda, CA or PE-Applied Biosystems, Foster City, CA) is attached to the 5' end of the probe and a quencher dye (e.g., TAMRA, obtained from either Operon Technologies Inc., Alameda, CA or PE-Applied Biosystems, Foster City, CA) is attached to the 3' end of the probe. When the probe and dyes are intact, reporter dye emission is quenched by the proximity of the 3' quencher dye. During amplification, annealing of the probe to the target sequence creates a substrate that can be cleaved by the 5'-exonuclease activity of Taq

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polymerase. During the extension phase of the PCR amplification cycle, cleavage of the probe by Taq polymerase releases the reporter dye from the remainder of the probe (and hence from the quencher moiety) and a sequence-specific fluorescent signal is generated. With each cycle, additional reporter dye molecules are cleaved from their respective probes, and the fluorescence intensity is monitored at regular intervals by laser optics built into the ABI PRISM™ 7700 Sequence Detection System. In each assay, a series of parallel reactions containing serial dilutions of mRNA from untreated control samples generates a standard curve that is used to quantitate the percent inhibition after antisense oligonucleotide treatment of test samples.

Prior to quantitative PCR analysis, primer-probe sets specific to the target gene being measured are evaluated for their ability to be "multiplexed" with a GAPDH amplification reaction. In multiplexing, both the target gene and the internal standard gene GAPDH are amplified concurrently in a single sample. In this analysis, mRNA isolated from untreated cells is serially diluted. Each dilution is amplified in the presence of primer-probe sets specific for GAPDH only, target gene only ("single-plexing"), or both (multiplexing). Following PCR amplification, standard curves of GAPDH and target mRNA signal as a function of dilution are generated from both the single-plexed and multiplexed samples. If both the slope and correlation coefficient of the GAPDH and target signals generated from the multiplexed samples fall within 10% of their corresponding values generated from the single-plexed samples, the primer-probe set specific for that target is deemed multiplexable. Other methods of PCR are also known in the art.

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PCR reagents were obtained from PE-Applied Biosystems, Foster City, CA. RT-PCR reactions were carried out by adding 25 μ L PCR cocktail (1x TAQMANTM buffer A, 5.5 mM MgCl₂, 300 μ M each of dATP, dCTP and dGTP, 5 600 μ M of dUTP, 100 nM each of forward primer, reverse primer, and probe, 20 Units RNase inhibitor, 1.25 Units AMPLITAQ GOLDTM, and 12.5 Units MuLV reverse transcriptase) to 96 well plates containing 25 μ L total RNA solution. The RT reaction was carried out by incubation for 30 10 minutes at 48°C. Following a 10 minute incubation at 95°C to activate the AMPLITAQ GOLDTM, 40 cycles of a two-step PCR protocol were carried out: 95°C for 15 seconds (denaturation) followed by 60°C for 1.5 minutes (annealing/extension).

15 Gene target quantities obtained by real time RT-PCR are normalized using either the expression level of GAPDH, a gene whose expression is constant, or by quantifying total RNA using RiboGreenTM (Molecular Probes, Inc. Eugene, OR). GAPDH expression is quantified by real time RT-PCR, 20 by being run simultaneously with the target, multiplexing, or separately. Total RNA is quantified using RiboGreenTM RNA quantification reagent from Molecular Probes. Methods of RNA quantification by RiboGreenTM are taught in Jones, L.J., et al, *Analytical Biochemistry*, 1998, 265, 368-374.

25 In this assay, 175 μ L of RiboGreenTM working reagent (RiboGreenTM reagent diluted 1:2865 in 10mM Tris-HCl, 1 mM EDTA, pH 7.5) is pipetted into a 96-well plate containing 25uL purified, cellular RNA. The plate is read in a CytoFluor 4000 (PE Applied Biosystems) with excitation at 30 480nm and emission at 520nm.

Probes and primers to human apolipoprotein B were designed to hybridize to a human apolipoprotein B

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sequence, using published sequence information (GenBank accession number NM_000384, incorporated herein as SEQ ID NO: 3). For human apolipoprotein B the PCR primers were: forward primer: TGCTAAAGGCACATATGGCCT (SEQ ID NO: 4)

5 reverse primer: CTCAGGTTGGACTCTCCATTGAG (SEQ ID NO: 5) and the PCR probe was: FAM-CTTGTCAGAGGGATCCTAACACTGGCCG-TAMRA (SEQ ID NO: 6) where FAM (PE-Applied Biosystems, Foster City, CA) is the fluorescent reporter dye) and TAMRA (PE-Applied Biosystems, Foster City, CA) is the quencher dye.

10 For human GAPDH the PCR primers were: forward primer: GAAGGTGAAGGTCGGAGTC (SEQ ID NO: 7) reverse primer: GAAGATGGTGGATGGGATTTC (SEQ ID NO: 8) and the PCR probe was: 5' JOE-CAAGCTTCCCGTTCTCAGCC-TAMRA 3' (SEQ ID NO: 9) where JOE (PE-Applied Biosystems, Foster

15 City, CA) is the fluorescent reporter dye) and TAMRA (PE-Applied Biosystems, Foster City, CA) is the quencher dye.

Probes and primers to mouse apolipoprotein B were designed to hybridize to a mouse apolipoprotein B sequence, using published sequence information (GenBank

20 accession number M35186, incorporated herein as SEQ ID NO: 10). For mouse apolipoprotein B the PCR primers were: forward primer: CGTGGGCTCCAGCATTCTA (SEQ ID NO: 11) reverse primer: AGTCATTTCTGCCTTTGCGTC (SEQ ID NO: 12) and the PCR probe was: FAM-CCAATGGTCGGGCACTGCTCAA-TAMRA

25 (SEQ ID NO: 13) where FAM (PE-Applied Biosystems, Foster City, CA) is the fluorescent reporter dye) and TAMRA (PE-Applied Biosystems, Foster City, CA) is the quencher dye.

For mouse GAPDH the PCR primers were: forward primer: GGCAAATTCAACGGCACAGT (SEQ ID NO: 14)

30 reverse primer: GGGTCTCGCTCCTGGAAGAT (SEQ ID NO: 15) and the PCR probe was: 5' JOE-AAGGCCGAGAATGGGAAGCTTGTCATC-TAMRA 3' (SEQ ID NO: 16) where JOE (PE-Applied Biosystems, Foster City, CA) is the fluorescent reporter dye) and

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TAMRA (PE-Applied Biosystems, Foster City, CA) is the quencher dye.

Example 14**Northern blot analysis of apolipoprotein B mRNA levels**

5 Eighteen hours after antisense treatment, cell monolayers were washed twice with cold PBS and lysed in 1 mL RNAZOL™ (TEL-TEST "B" Inc., Friendswood, TX). Total RNA was prepared following manufacturer's recommended protocols. Twenty micrograms of total RNA was
10 fractionated by electrophoresis through 1.2% agarose gels containing 1.1% formaldehyde using a MOPS buffer system (AMRESCO, Inc. Solon, OH). RNA was transferred from the gel to HYBOND™-N+ nylon membranes (Amersham Pharmacia Biotech, Piscataway, NJ) by overnight capillary transfer
15 using a Northern/Southern Transfer buffer system (TEL-TEST "B" Inc., Friendswood, TX). RNA transfer was confirmed by UV visualization. Membranes were fixed by UV cross-linking using a STRATALINKER™ UV Crosslinker 2400 (Stratagene, Inc, La Jolla, CA) and then robed using
20 QUICKHYB™ hybridization solution (Stratagene, La Jolla, CA) using manufacturer's recommendations for stringent conditions.

 To detect human apolipoprotein B, a human apolipoprotein B specific probe was prepared by PCR using
25 the forward primer TGCTAAAGGCACATATGGCCT (SEQ ID NO: 4) and the reverse primer CTCAGGTTGGACTCTCCATTGAG (SEQ ID NO: 5). To normalize for variations in loading and transfer efficiency membranes were stripped and probed for human glyceraldehyde-3-phosphate dehydrogenase (GAPDH) RNA
30 (Clontech, Palo Alto, CA).

 To detect mouse apolipoprotein B, a human apolipoprotein B specific probe was prepared by PCR using

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the forward primer CGTGGGCTCCAGCATTCTA (SEQ ID NO: 11) and the reverse primer AGTCATTTCTGCCTTTGCGTC (SEQ ID NO: 12). To normalize for variations in loading and transfer efficiency membranes were stripped and probed for mouse
5 glycerinaldehyde-3-phosphate dehydrogenase (GAPDH) RNA (Clontech, Palo Alto, CA).

Hybridized membranes were visualized and quantitated using a PHOSPHORIMAGER™ and IMAGEQUANT™ Software V3.3 (Molecular Dynamics, Sunnyvale, CA). Data was normalized
10 to GAPDH levels in untreated controls.

Example 15

Antisense inhibition of human apolipoprotein B expression by chimeric phosphorothioate oligonucleotides having 2'-MOE wings and a deoxy gap

15 In accordance with the present invention, a series of oligonucleotides were designed to target different regions of the human apolipoprotein B RNA, using published sequence (GenBank accession number NM_000384, incorporated herein as SEQ ID NO: 3). The oligonucleotides are shown
20 in Table 1. "Target site" indicates the first (5'-most) nucleotide number on the particular target sequence to which the oligonucleotide binds. All compounds in Table 1 are chimeric oligonucleotides ("gapmers") 20 nucleotides in length, composed of a central "gap" region consisting
25 of ten 2'-deoxynucleotides, which is flanked on both sides (5' and 3' directions) by five-nucleotide "wings". The wings are composed of 2'-methoxyethyl (2'-MOE)nucleotides. The internucleoside (backbone) linkages are phosphorothioate (P=S) throughout the oligonucleotide.
30 All cytidine residues are 5-methylcytidines. The compounds were analyzed for their effect on human apolipoprotein B mRNA levels in HepG2 cells by quantitative real-time PCR as described in other examples

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herein. Data are averages from two experiments. If present, "N.D." indicates "no data".

Table 1

- 5 Inhibition of human apolipoprotein B mRNA levels by chimeric phosphorothioate oligonucleotides having 2'-MOE wings and a deoxy gap

ISIS #	REGION	TARGET SEQ ID NO	TARGET SITE	SEQUENCE	%INHIB	SEQ ID NO
147780	5'UTR	3	1	CCGCAGGTCCCGGTGGGAAT	40	17
147781	5'UTR	3	21	ACCGAGAAGGGCACTCAGCC	35	18
147782	5'UTR	3	71	GCCTCGGCCTCGCGGCCCTG	67	19
147783	Start Codon	3	114	TCCATCGCCAGCTGCGGTGG	N.D.	20
147784	Coding	3	151	CAGCGCCAGCAGCGCCAGCA	70	21
147785	Coding	3	181	GCCCCGCCAGCAGCAGCAGCA	29	22
147786	Coding	3	321	CTTGAATCAGCAGTCCAGG	34	23
147787	Coding	3	451	CTTCAGCAAGGCTTTGCCCT	N.D.	24
147788	Coding	3	716	TTTCTGTTGCCACATTGCCC	95	25
147789	Coding	3	911	GGAAGAGGTGTTGCTCCTTG	24	26
147790	Coding	3	951	TGTGCTACCATCCCATACTT	33	27
147791	Coding	3	1041	TCAAATGCGAGGCCCATCTT	N.D.	28
147792	Coding	3	1231	GGACACCTCAATCAGCTGTG	26	29
147793	Coding	3	1361	TCAGGGCCACCAGGTAGGTG	N.D.	30
147794	Coding	3	1561	GTAATCTTCATCCCCAGTGC	47	31
147795	Coding	3	1611	TGCTCCATGGTTTGGCCCAT	N.D.	32
147796	Coding	3	1791	GCAGCCAGTCGCTTATCTCC	8	33
147797	Coding	3	2331	GTATAGCCAAAGTGGTCCAC	N.D.	34
147798	Coding	3	2496	CCCAGGAGCTGGAGGTCATG	N.D.	35
147799	Coding	3	2573	TTGAGCCCTTCTTGATGACC	N.D.	36
147800	Coding	3	2811	ATCTGGACCCCACTCCTAGC	N.D.	37
147801	Coding	3	2842	CAGACCCGACTCGTGGAAGA	38	38
147802	Coding	3	3367	GCCCTCAGTAGATTCATCAT	N.D.	39
147803	Coding	3	3611	GCCATGCCACCCTCTTGGA	N.D.	40
147804	Coding	3	3791	AACCCACGTGCCGAAAGTC	N.D.	41
147805	Coding	3	3841	ACTCCCAGATGCC'TTCTGAA	N.D.	42
147806	Coding	3	4281	ATGTGGTAACGAGCCCGAAG	100	43
147807	Coding	3	4391	GGCGTAGAGACCCATCACAT	25	44
147808	Coding	3	4641	GTGTTAGGATCCCCTCTGACA	N.D.	45
147809	Coding	3	5241	CCCAGTGATAGCTCTGTGAG	60	46
147810	Coding	3	5355	ATTTACAGCATATGAGCCCAT	0	47
147811	Coding	3	5691	CCCTGAACCTTAGCAACAGT	N.D.	48
147812	Coding	3	5742	GCTGAAGCCAGCCAGCGAT	N.D.	49
147813	Coding	3	5891	ACAGCTGCCCAAGTATGTTCT	N.D.	50
147814	Coding	3	7087	CCCAATAAGATT'TATAACAA	34	51
147815	Coding	3	7731	TGGCCTACCAGAGACAGGTA	45	52
147816	Coding	3	7841	TCATACGTTT'TAGCCCAATCT	100	53
147817	Coding	3	7901	GCATGGTCCCAAGGATGGTC	0	54
147818	Coding	3	8491	AGTGATGGAAGCTGCGATAC	30	55
147819	Coding	3	9181	ATGAGCATCATGCCTCCAG	N.D.	56

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147820	Coding	3	9931	GAACACATAGCCGAATGCCG	100	57
147821	Coding	3	10263	GTGGTGCCCTCTAATTGTGA	N.D.	58
147822	Coding	3	10631	CCCGAGAAAGAACCGAACCC	N.D.	59
147823	Coding	3	10712	TGCCCTGCAGCTTCACTGAA	19	60
147824	Coding	3	11170	GAAATCCCATAAGCTCTTGT	N.D.	61
147825	Coding	3	12301	AGAAGCTGCCTCTTCTTCCC	72	62
147826	Coding	3	12401	TCAGGGTGAGCCCTGTGTGT	80	63
147827	Coding	3	12471	CTAATGGCCCTTGATAAAC	13	64
147828	Coding	3	12621	ACGTTATCCTTGAGTCCCTG	12	65
147829	Coding	3	12741	TATATCCAGGTTTCCCCCGG	64	66
147830	Coding	3	12801	ACCTGGGACAGTACCGTCCC	N.D.	67
147831	3'UTR	3	13921	CTGCCTACTGCAAGGCTGGC	0	68
147832	3'UTR	3	13991	AGAGACCTTCCGAGCCCTGG	N.D.	69
147833	3'UTR	3	14101	ATGATACACAATAAAGACTC	25	70

As shown in Table 1, SEQ ID NOS 17, 18, 19, 21, 23, 25, 27, 31, 38, 43, 46, 51, 52, 53, 55, 57, 62, 63 and 66 demonstrated at least 30% inhibition of human apolipoprotein B expression in this assay and are therefore preferred. The target sites to which these preferred sequences are complementary are herein referred to as "active sites" and are therefore preferred sites for targeting by compounds of the present invention. As apolipoprotein B exists in two forms in mammals (ApoB-48 and ApoB-100) which are colinear at the amino terminus, antisense oligonucleotides targeting nucleotides 1-6530 hybridize to both forms, while those targeting nucleotides 6531-14121 are specific to the long form of apolipoprotein B.

Example 16

Antisense inhibition of human apolipoprotein B expression by chimeric phosphorothioate oligonucleotides having 2'-MOE wings and a deoxy gap-Dose Response Study

In accordance with the present invention, a subset of the antisense oligonucleotides in Example 15 were further investigated in dose-response studies. Treatment doses were 50, 150 and 250 nM. The compounds were analyzed for their effect on human apolipoprotein B mRNA levels in HepG2 cells by quantitative real-time PCR as described in

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other examples herein. Data are averages from two experiments and are shown in Table 2.

Table 2

- 5 Inhibition of human apolipoprotein B mRNA levels by
chimeric phosphorothioate oligonucleotides having 2'-MOE
wings and a deoxy gap

ISIS #	Percent Inhibition		
	50 nM	150 nM	250 nM
147788	54	63	72
147806	23	45	28
147816	25	81	65
147820	10	0	73

Example 17

- 10 **Antisense inhibition of mouse apolipoprotein B expression
by chimeric phosphorothioate oligonucleotides having 2'-
MOE wings and a deoxy gap**

In accordance with the present invention, a series of oligonucleotides were designed to target different regions
15 of the mouse apolipoprotein B RNA, using published sequence (GenBank accession number M35186, incorporated herein as SEQ ID NO: 10). The oligonucleotides are shown in Table 3. "Target site" indicates the first (5'-most) nucleotide number on the particular target sequence to
20 which the oligonucleotide binds. All compounds in Table 3 are chimeric oligonucleotides ("gapmers") 20 nucleotides in length, composed of a central "gap" region consisting of ten 2'-deoxynucleotides, which is flanked on both sides (5' and 3' directions) by five-nucleotide "wings". The
25 wings are composed of 2'-methoxyethyl (2'-MOE) nucleotides. The internucleoside (backbone) linkages are phosphorothioate (P=S) throughout the oligonucleotide. All cytidine residues are 5-methylcytidines. The compounds were analyzed for their effect on mouse

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apolipoprotein B mRNA levels in primary hepatocytes by quantitative real-time PCR as described in other examples herein. Data are averages from two experiments. If present, "N.D." indicates "no data".

5

Table 3

Inhibition of mouse apolipoprotein B mRNA levels by chimeric phosphorothioate oligonucleotides having 2'-MOE wings and a deoxy gap

10

ISIS #	REGION	TARGET SEQ ID NO	TARGET SITE	SEQUENCE	%INHIB	SEQ ID NO
147475	Coding	10	13	ATTGTATGTGAGAGGTGAGG	79	71
147476	Coding	10	66	GAGGAGATTGGATCTTAAGG	13	72
147477	Coding	10	171	CTTCAAATTGGGACTCTCCT	N.D	73
147478	Coding	10	211	TCCAGGAATTGAGCTTGTGC	78	74
147479	Coding	10	238	TTCAGGACTGGAGGATGAGG	N.D	75
147480	Coding	10	291	TCTCACCTCATGCTCCATT	54	76
147481	Coding	10	421	TGACTGTCAAGGGTGAGCTG	24	77
147482	Coding	10	461	GTCCAGCCTAGGAACACTCA	59	78
147483	Coding	10	531	ATGTCAATGCCACATGTCCA	N.D	79
147484	Coding	10	581	TTCATCCGAGAAGTTGGGAC	49	80
147485	Coding	10	601	ATTTGGGACGAATGTATGCC	64	81
147486	Coding	10	711	AGTTGAGGAAGCCAGATTCA	N.D	82
147487	Coding	10	964	TTCCCAGTCAGCTTTAGTGG	73	83
147488	Coding	10	1023	AGCTTGCTTGTGGGCACGG	72	84
147489	Coding	10	1111	CCTATACTGGCTTCTATGTT	5	85
147490	Coding	10	1191	TGAAGTCCGTGTAAGGCAAG	N.D	86
147491	Coding	10	1216	GAGAAATCCTTCAGTAAGGG	71	87
147492	Coding	10	1323	CAATGGAATGCTTGTCACTG	68	88
147493	Coding	10	1441	GCTTCATTATAGGAGGTGGT	41	89
147494	Coding	10	1531	ACAAGTGGGATAGTGTAGCC	84	90
147495	Coding	10	1631	GTTAGGACCAGGGATTGTGA	0	91
147496	Coding	10	1691	ACCATGGAAAAGTGGCAACT	19	92
147497	Coding	10	1721	TGGGAGGAAAAAGTGAATA	N.D	93
147498	Coding	10	1861	TGGGCAACGATATCTGATTG	0	94
147499	Coding	10	1901	CTGCAGGGCGTCAGTGACAA	29	95
147500	Coding	10	1932	GCATCAGACGTGATGTTCCC	N.D	96
147501	Coding	10	2021	CTTGGTTAACTAATGGTGC	18	97
147502	Coding	10	2071	ATGGGAGCATGGAGGTTGGC	16	98
147503	Coding	10	2141	AATGGATGATGAAACAGTGG	26	99
147504	Coding	10	2201	ATCAATGCCTCCTGTTGCAG	N.D	100
147505	Coding	10	2231	GGAAGTGAGACTTTCTAAGC	76	101
147506	Coding	10	2281	AGGAAGGAACTCTTGATATT	58	102
147507	Coding	10	2321	ATTGGCTTCATTGGCAACAC	81	103
147759	Coding	10	1	AGGTGAGGAAGTTGGAATTC	19	104
147760	Coding	10	121	TTGTTCCTGAAAGTTGTTAC	N.D	105
147761	Coding	10	251	GTTTCATGGATTCCTTCAGGA	45	106
147762	Coding	10	281	ATGCTCCATTCTCACATGCT	46	107

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147763	Coding	10	338	TGCGACTGTGTCTGATTTCC	34	108
147764	Coding	10	541	GTCCCTGAAGATGTCAATGC	97	109
147765	Coding	10	561	AGGCCCAGTTCCATGACCCT	59	110
147766	Coding	10	761	GGAGCCCACGTGCTGAGATT	59	111
147767	Coding	10	801	CGTCCTTGAGCAGTGCCCGA	5	112
147768	Coding	10	1224	CCCATATGGAGAAATCCTTC	24	113
147769	Coding	10	1581	CATGCCTGGAAGCCAGTGTC	89	114
147770	Coding	10	1741	GTGTTGAATCCCTTGAAATC	67	115
147771	Coding	10	1781	GGTAAAGTTGCCCATGGCTG	68	116
147772	Coding	10	1841	GTTATAAAGTCCAGCATTGG	78	117
147773	Coding	10	1931	CATCAGACGTGATGTTCCCT	85	118
147774	Coding	10	1956	TGGCTAGTTTCAATCCCCTT	84	119
147775	Coding	10	2002	CTGTCACTGACTGCCCTTTAC	52	120
147776	Coding	10	2091	GCTTGAAGTTCATTGAGAAT	92	121
147777	Coding	10	2291	TTCTTGAGAAAGGAAGGAAC	N.D	122
147778	Coding	10	2331	TCAGATATACATTGGCTTCA	14	123

As shown in Table 3, SEQ ID Nos 71, 74, 76, 78, 81, 83, 84, 87, 88, 90, 101, 102, 103, 109, 111, 111, 114, 115, 116, 117, 118, 119, 120 and 121 demonstrated at least 50% inhibition of mouse apolipoprotein B expression in this assay and are therefore preferred. The target sites to which these preferred sequences are complementary are herein referred to as "active sites" and are therefore preferred sites for targeting by compounds of the present invention.

Example 18

Antisense inhibition mouse apolipoprotein B expression by chimeric phosphorothioate oligonucleotides having 2'-MOE wings and a deoxy gap- Dose Response Study

In accordance with the present invention, a subset of the antisense oligonucleotides in Example 17 were further investigated in dose-response studies. Treatment doses were 50, 150 and 300 nM. The compounds were analyzed for their effect on mouse apolipoprotein B mRNA levels in primary hepatocytes cells by quantitative real-time PCR as described in other examples herein. Data are averages from two experiments and are shown in Table 4.

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Table 4

Inhibition of mouse apolipoprotein B mRNA levels by
chimeric phosphorothioate oligonucleotides having 2'-MOE
wings and a deoxy gap

ISIS #	Percent Inhibition		
	50 nM	150 nM	300 nM
147483	56	88	89
147764	48	84	90
147769	3	14	28
147776	0	17	44

5

Example 19**Western blot analysis of apolipoprotein B protein levels**

Western blot analysis (immunoblot analysis) was
carried out using standard methods. Cells were harvested
10 16-20 h after oligonucleotide treatment, washed once with
PBS, suspended in Laemmli buffer (100 ul/well), boiled for
5 minutes and loaded on a 16% SDS-PAGE gel. Gels were run
for 1.5 hours at 150 V, and transferred to membrane for
western blotting. Appropriate primary antibody directed
15 to apolipoprotein B was used, with a radiolabelled or
fluorescently labeled secondary antibody directed against
the primary antibody species. Bands were visualized using
a PHOSPHORIMAGER™ (Molecular Dynamics, Sunnyvale CA).

Example 20

20 **Effects of antisense inhibition of apolipoprotein B (ISIS
147764) in C57BL/6 mice: Lean animals vs. High Fat Fed
animals.**

C57BL/6 mice, a strain reported to be susceptible to
hyperlipidemia-induced atherosclerotic plaque formation
25 were used in the following studies to evaluate antisense
oligonucleotides as potential lipid lowering compounds in
lean versus high fat fed mice.

Male C57BL/6 mice were divided into two matched
groups; (1) wild-type control animals (lean animals) and

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(2) animals receiving a high fat diet (60% kcal fat). Control animals received saline treatment and were maintained on a normal rodent diet. After overnight fasting, mice from each group were dosed intraperitoneally every three days with saline or 50 mg/kg ISIS 147764 (SEQ ID No: 109) for six weeks. At study termination and forty eight hours after the final injections, animals were sacrificed and evaluated for target mRNA levels in liver, cholesterol and triglyceride levels, liver enzyme levels and serum glucose levels.

The results of the comparative studies are shown in Table 5.

Table 5

Effects of ISIS 147764 treatment on apolipoprotein B mRNA, cholesterol, lipid, triglyceride, liver enzyme and glucose levels in lean and high fat mice.

Treatment Group	Percent Change								
	mRNA	CHOL	Lipoproteins			TRIG	Liver Enzymes		GLUC
Lean-control	-73	-63	No change	-64	-44	-34	Slight decrease	No change	No change
High Fat Group	-87	-67	No change	-87	-65	No change	Slight decrease	Slight increase	-28

It is evident from these data that treatment with ISIS 147764 lowered cholesterol as well as LDL and HDL lipoproteins and serum glucose in both lean and high fat mice and that the effects demonstrated are, in fact, due to the inhibition of apolipoprotein B expression as supported by the decrease in mRNA levels. No significant changes in liver enzyme levels were observed, indicating that the antisense oligonucleotide was not toxic to either treatment group.

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Example 21**Effects of antisense inhibition of apolipoprotein B (ISIS 147764) on High Fat Fed Mice; 6 Week Timecourse Study**

In accordance with the present invention, a 6-week
5 timecourse study was performed to further investigate the
effects of ISIS 147764 on lipid and glucose metabolism in
high fat fed mice.

Male C57BL/6 mice (n=8) receiving a high fat diet
(60% kcal fat) were evaluated over the course of 6 weeks
10 for the effects of treatment with the antisense
oligonucleotide, ISIS 147764. Control animals received
saline treatment (50 mg/kg). A subset of animals received
a daily oral dose (20 mg/kg) atorvastatin calcium
(Lipitor®, Pfizer Inc.). All mice, except atorvastatin-
15 treated animals, were dosed intraperitoneally every three
days (twice a week), after fasting overnight, with 5, 25,
50 mg/kg ISIS 147764 (SEQ ID No: 109) or saline (50 mg/kg)
for six weeks. Serum cholesterol and lipoproteins were
analyzed at 0, 2 and 6 week interim timepoints. At study
20 termination, animals were sacrificed 48 hours after the
final injections and evaluated for levels of target mRNA
levels in liver, cholesterol, lipoprotein, triglyceride,
liver enzyme (AST and ALT) and serum glucose levels as
well as body, liver, spleen and fat pad weights.

25 Example 22**Effects of antisense inhibition of apolipoprotein B (ISIS 147764) in high fat fed mice- mRNA expression in liver**

Male C57BL/6 mice (n=8) receiving a high fat diet
(60% kcal fat) were evaluated over the course of 6 weeks
30 for the effects of ISIS 147764 on mRNA expression.
Control animals received saline treatment (50 mg/kg). Mice
were dosed intraperitoneally every three days (twice a
week), after fasting overnight, with 5, 25, 50 mg/kg ISIS

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147764 (SEQ ID No: 109) or saline (50 mg/kg) for six weeks. At study termination, animals were sacrificed 48 hours after the final injections and evaluated for levels of target mRNA levels in liver. ISIS 147764 showed a dose-response effect, reducing mRNA levels by 15, 75 and 88% at doses of 5, 25 and 50 mg/kg, respectively.

Example 23**Effects of antisense inhibition of apolipoprotein B (ISIS 147764) on serum cholesterol and triglyceride levels**

Male C57BL/6 mice (n=8) receiving a high fat diet (60% kcal fat) were evaluated over the course of 6 weeks for the effects of ISIS 147764 on serum cholesterol and triglyceride levels. Control animals received saline treatment (50 mg/kg). Mice were dosed intraperitoneally every three days (twice a week), after fasting overnight, with 5, 25, 50 mg/kg ISIS 147764 (SEQ ID No: 109) or saline (50 mg/kg) for six weeks.

Serum cholesterol levels were measured at 0, 2 and 6 weeks and this data is shown in Table 6. Values in the table are expressed as percent inhibition and are normalized to the saline control.

In addition to serum cholesterol, at study termination, animals were sacrificed 48 hours after the final injections and evaluated for triglyceride levels.

Mice treated with ISIS 147764 showed a reduction in both serum cholesterol (240 mg/dL for control animals and 225, 125 and 110 mg/dL for doses of 5, 25, and 50 mg/kg, respectively) and triglycerides (115 mg/dL for control animals and 125, 150 and 85 mg/dL for doses of 5, 25, and 50 mg/kg, respectively) to normal levels by study end. These data were also compared to the effects of atorvastatin calcium at an oral dose of 20 mg/kg which

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showed only a minimal decrease in serum cholesterol of 20 percent at study termination.

Table 6

Percent Inhibition of mouse apolipoprotein B cholesterol levels by ISIS 147764

5

time	Percent Inhibition			
	Saline	5 mg/kg	25 mg/kg	50 mg/kg
0 weeks	0	0	0	0
2 weeks	0	5	12	20
6 weeks	0	10	45	55

Example 24**Effects of antisense inhibition of apolipoprotein B (ISIS 147764) on lipoprotein levels**

10

Male C57BL/6 mice (n=8) receiving a high fat diet (60% kcal fat) were evaluated over the course of 6 weeks for the effects of ISIS 147764 on lipoprotein (VLDL, LDL and HDL) levels. Control animals received saline treatment (50 mg/kg). Mice were dosed intraperitoneally every three days (twice a week), after fasting overnight, with 5, 25, 50 mg/kg ISIS 147764 (SEQ ID No: 109) or saline (50 mg/kg) for six weeks.

15

Lipoprotein levels were measured at 0, 2 and 6 weeks and this data is shown in Table 7. Values in the table are expressed as percent inhibition and are normalized to the saline control. Negative values indicate an observed increase in lipoprotein levels.

20

These data were also compared to the effects of atorvastatin calcium at a daily oral dose of 20 mg/kg at 0, 2 and 6 weeks.

25

These data demonstrate that at a dose of 50 mg/kg, ISIS 147764 is capable of lowering all categories of serum lipoproteins investigated to a greater extent than atorvastatin.

30

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Table 7

Percent Inhibition of mouse apolipoprotein B lipoprotein levels by ISIS 147764 as compared to atorvastatin

Lipoprotein	Time (weeks)	Percent Inhibition				
		Dose				atorvastatin (20 mg/kg)
		Saline	5 mg/kg	25 mg/kg	50 mg/kg	
VLDL	0	0	0	0	0	0
	2	0	25	30	40	15
	6	0	10	-30	15	-5
LDL	0	0	0	0	0	0
	2	0	-30	10	40	10
	6	0	-10	55	90	-10
HDL	0	0	0	0	0	0
	2	0	5	10	10	15
	6	0	10	45	50	20

5

Example 25

Effects of antisense inhibition of apolipoprotein B (ISIS 147764) on serum AST and ALT levels

Male C57BL/6 mice (n=8) receiving a high fat diet (60% kcal fat) were evaluated over the course of 6 weeks for the effects of ISIS 147764 on liver enzyme (AST and ALT) levels. Control animals received saline treatment (50 mg/kg). Mice were dosed intraperitoneally every three days (twice a week), after fasting overnight, with 5, 25, 50 mg/kg ISIS 147764 (SEQ ID No: 109) or saline (50 mg/kg) for six weeks.

AST and ALT levels were measured at 6 weeks and this data is shown in Table 8. Values in the table are expressed as IU/L. Increased levels of the liver enzymes ALT and AST indicate toxicity and liver damage.

Mice treated with ISIS 147764 showed no significant change in AST levels over the duration of the study compared to saline controls (105, 70 and 80 IU/L for doses of 5, 25 and 50 mg/kg, respectively compared to 65 IU/L for saline control). Mice treated with atorvastatin at a

25

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daily oral dose of 20 mg/kg had AST levels of 85 IU/L.

ALT levels were increased by all treatments over the duration of the study compared to saline controls (50, 70 and 100 IU/L for doses of 5, 25 and 50 mg/kg, respectively compared to 25 IU/L for saline control). Mice treated with atorvastatin at a daily oral dose of 20 mg/kg had AST levels of 40 IU/L.

Example 26

Effects of antisense inhibition of apolipoprotein B (ISIS 147764) on serum glucose levels

Male C57BL/6 mice (n=8) receiving a high fat diet (60% kcal fat) were evaluated over the course of 6 weeks for the effects of ISIS 147764 on serum glucose levels. Control animals received saline treatment (50 mg/kg). Mice were dosed intraperitoneally every three days (twice a week), after fasting overnight, with 5, 25, 50 mg/kg ISIS 147764 (SEQ ID No: 109) or saline (50 mg/kg) for six weeks.

At study termination, animals were sacrificed 48 hours after the final injections and evaluated for serum glucose levels. ISIS 147764 showed a dose-response effect, reducing serum glucose levels to 225, 190 and 180 mg/dL at doses of 5, 25 and 50 mg/kg, respectively compared to the saline control of 300 mg/dL. Mice treated with atorvastatin at a daily oral dose of 20 mg/kg had serum glucose levels of 215 mg/dL. These data demonstrate that ISIS 147764 is capable of reducing serum glucose levels in high fat fed mice.

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Example 27**Effects of antisense inhibition of apolipoprotein B (ISIS 147764) on body, spleen, liver and fat pad weight**

5 Male C57BL/6 mice (n=8) receiving a high fat diet (60% kcal fat) were evaluated over the course of 6 weeks for the effects of ISIS 147764 on body, spleen, liver and fat pad weight. Control animals received saline treatment (50 mg/kg). Mice were dosed intraperitoneally every three
 10 days (twice a week), after fasting overnight, with 5, 25, 50 mg/kg ISIS 147764 (SEQ ID No: 109) or saline (50 mg/kg) for six weeks.

At study termination, animals were sacrificed 48 hours after the final injections and body, spleen, liver
 15 and fat pad weights were measured. These data are shown in Table 8. Values are expressed as percent change in body weight or organ weight compared to the saline-treated control animals. Data from mice treated with atorvastatin at a daily dose of 20 mg/kg are also shown in the table.
 20 Negative values indicated a decrease in weight.

Table 8

Effects of antisense inhibition of mouse apolipoprotein B
 on body and organ weight

25

	Percent Change			Atorvastatin 20 mg/kg
	Dose			
Tissue	5 mg/kg	25 mg/kg	50 mg/kg	
Total Body Wt.	5	5	-4	1
Spleen	10	10	46	10
Liver	18	70	80	15
Fat	10	6	-47	7

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These data show a decrease in fat over the dosage range of ISIS 147764 counterbalanced by an increase in both spleen and liver weight with increased dose to give an overall decrease in total body weight.

5 **Example 28**

Effects of antisense inhibition of apolipoprotein B (ISIS 147764) in B6.129P-ApoE^{tm1Unc} knockout mice: Lean animals vs. High Fat Fed animals.

10 B6.129P-ApoE^{tm1Unc} knockout mice (herein referred to as ApoE knockout mice) obtained from The Jackson Laboratory (Bar Harbor, ME), are homozygous for the ApoE^{tm1Unc} mutation and show a marked increase in total plasma cholesterol levels that are unaffected by age or sex. These animals present with fatty streaks in the proximal aorta at 3
15 months of age. These lesions increase with age and progress to lesions with less lipid but more elongated cells, typical of a more advanced stage of pre-atherosclerotic lesion.

20 The mutation in these mice resides in the apolipoprotein E (ApoE) gene. The primary role of the ApoE protein is to transport cholesterol and triglycerides throughout the body. It stabilizes lipoprotein structure, binds to the low density lipoprotein receptor (LDLR) and related proteins, and is present in a subclass of HDLs,
25 providing them the ability to bind to LDLR. ApoE is expressed most abundantly in the liver and brain. Female B6.129P-ApoE^{tm1Unc} knockout mice (ApoE knockout mice) were used in the following studies to evaluate antisense oligonucleotides as potential lipid lowering compounds.

30 Female ApoE knockout mice ranged in age from 5 to 7 weeks and were placed on a normal diet for 2 weeks before study initiation. ApoE knockout mice were then fed *ad libitum* a 60% fat diet, with 0.15% added cholesterol to

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induce dyslipidemia and obesity. Control animals were maintained on a high-fat diet with no added cholesterol. After overnight fasting, mice from each group were dosed intraperitoneally every three days with saline, 50 mg/kg of a control antisense oligonucleotide (ISIS 29837 TCGATCTCCTTTTATGCCCG; SEQ ID NO. 124) or 5, 25 or 50 mg/kg ISIS 147764 (SEQ ID No: 109) for six weeks.

The control oligonucleotide is a chimeric oligonucleotides ("gapmers") 20 nucleotides in length, composed of a central "gap" region consisting of ten 2'-deoxynucleotides, which is flanked on both sides (5' and 3' directions) by five-nucleotide "wings". The wings are composed of 2'-methoxyethyl (2'-MOE)nucleotides. The internucleoside (backbone) linkages are phosphorothioate (P=S) throughout the oligonucleotide. All cytidine residues are 5-methylcytidines.

At study termination and forty eight hours after the final injections, animals were sacrificed and evaluated for target mRNA levels in liver by RT-PCR methods verified by Northern Blot analysis, glucose levels, cholesterol and lipid levels by HPLC separation methods and triglyceride and liver enzyme levels (performed by LabCorp Preclinical Services; San Diego, CA). Data from ApoE knockout mice treated with atorvastatin at a daily dose of 20 mg/kg are also shown in the table for comparison. The results of the comparative studies are shown in Table 9. Data are normalized to saline controls.

Table 9

Effects of ISIS 147764 treatment on apolipoprotein B mRNA, cholesterol, glucose, lipid, triglyceride and liver enzyme levels in ApoE knockout mice.

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		Percent Inhibition				
		Dose				
		Control	5 mg/kg	25 mg/kg	50 mg/kg	atorvastatin (20 mg/kg)
mRNA		0	2	42	70	10
Glucose						
		Glucose Levels (mg/dL)				
		225	195	209	191	162
		Cholesterol Levels (mg/dL)				
Cholesterol		1750	1630	1750	1490	938
		Lipoprotein Levels (mg/dL)				
Lipoprotein	HDL	51	49	62	61	42
	LDL	525	475	500	325	250
	VLDL	1190	1111	1194	1113	653
		Liver Enzyme Levels (IU/L)				
Liver Enzymes	AST	55	50	60	85	75
	ALT	56	48	59	87	76

It is evident from these data that treatment with ISIS 147764 lowered glucose and cholesterol as well as all lipoproteins investigated (HDL, LDL and VLDL) in ApoE knockout mice. Further, these decreases correlated with a decrease in both protein and RNA levels of apolipoprotein B, demonstrating an antisense mechanism of action. No significant changes in liver enzyme levels were observed, indicating that the antisense oligonucleotide was not toxic to either treatment group.

What is claimed is:

- 5 1. A compound 8 to 50 nucleobases in length targeted to a nucleic acid molecule encoding apolipoprotein B, wherein said compound specifically hybridizes with and inhibits the expression of a nucleic acid molecule encoding apolipoprotein B.
- 10 2. The compound of claim 1 which is an antisense oligonucleotide.
3. The compound of claim 2 wherein the antisense oligonucleotide has a sequence comprising SEQ ID NO: 17, 18, 19, 20, 21, 23, 24, 25, 27, 28, 30, 31, 32, 34, 35, 15 36, 37, 38, 39, 40, 41, 42, 43, 45, 46, 48, 49, 50, 51, 52, 53, 55, 56, 57, 58, 59, 61, 62, 63, 66, 67, 69, 71, 73, 74, 75, 76, 78, 79, 81, 82, 83, 84, 86, 87, 88, 90, 93, 96, 101, 101, 102, 103, 105, 109, 111, 111, 114, 115, 116, 117, 118, 119, 120, 121 or 122.
- 20 4. The compound of claim 2 wherein the antisense oligonucleotide comprises at least one modified internucleoside linkage.
5. The compound of claim 4 wherein the modified internucleoside linkage is a phosphorothioate linkage.
- 25 6. The compound of claim 2 wherein the antisense oligonucleotide comprises at least one modified sugar moiety.
7. The compound of claim 6 wherein the modified sugar moiety is a 2'-O-methoxyethyl sugar moiety.
- 30 8. The compound of claim 2 wherein the antisense oligonucleotide comprises at least one modified nucleobase.

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9. The compound of claim 8 wherein the modified nucleobase is a 5-methylcytosine.

10. The compound of claim 2 wherein the antisense oligonucleotide is a chimeric oligonucleotide.

5 11. A compound 8 to 50 nucleobases in length which specifically hybridizes with at least an 8-nucleobase portion of an active site on a nucleic acid molecule encoding apolipoprotein B.

10 12. A composition comprising the compound of claim 1 and a pharmaceutically acceptable carrier or diluent.

13. The composition of claim 12 further comprising a colloidal dispersion system.

14. The composition of claim 12 wherein the compound is an antisense oligonucleotide.

15 15. A method of inhibiting the expression of apolipoprotein B in cells or tissues comprising contacting said cells or tissues with the compound of claim 1 so that expression of apolipoprotein B is inhibited.

16. A method of treating an animal having a disease or condition associated with apolipoprotein B comprising administering to said animal a therapeutically or prophylactically effective amount of the compound of claim 1 so that expression of apolipoprotein B is inhibited.

17. The method of claim 16 wherein the condition involves abnormal lipid metabolism.

18. The method of claim 16 wherein the condition involves abnormal cholesterol metabolism.

19. The method of claim 16 wherein the condition is atherosclerosis.

30 20. The compound of claim 1 targeted to a nucleic acid molecule encoding apolipoprotein B, wherein said compound specifically hybridizes with and inhibits the expression of the long form of a nucleic acid molecule

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encoding apolipoprotein B, ApoB-100.

21. The method of claim 16 wherein the condition is an abnormal metabolic condition.

22. The method of claim 21 wherein the abnormal
5 metabolic condition is hyperlipidemia.

23. The method of claim 16 wherein the disease is diabetes.

24. The method of claim 23 wherein the diabetes is Type 2 diabetes.

10 25. The method of claim 16 wherein the condition is obesity.

26. The method of claim 16 wherein the condition is atherosclerosis.

15 27. The method of claim 16 wherein the disease is cardiovascular disease.

28. A method of modulating glucose levels in an animal comprising administering to said animal the compound of claim 1.

20 29. The method of claim 28 wherein the animal is a human.

30. The method of claim 28 wherein the glucose levels are plasma glucose levels.

31. The method of claim 28 wherein the glucose levels are serum glucose levels.

25 32. The method of claim 28 wherein the animal is a diabetic animal.

33. A method of preventing or delaying the onset of a disease or condition associated with apolipoprotein B in an animal comprising administering to said animal a
30 therapeutically or prophylactically effective amount of the compound of claim 1.

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34. The method of claim 33 wherein the animal is a human.

35. The method of claim 33 wherein the condition is an abnormal metabolic condition.

5 36. The method of claim 35 wherein the abnormal metabolic condition is hyperlipidemia.

37. The method of claim 33 wherein the disease is diabetes.

10 38. The method of claim 37 wherein the diabetes is Type 2 diabetes.

39. The method of claim 33 wherein the condition is obesity.

40. The method of claim 33 wherein the condition is atherosclerosis.

15 41. The method of claim 33 wherein the condition involves abnormal lipid metabolism.

42. The method of claim 33 wherein the condition involves abnormal cholesterol metabolism.

20 43. A method of preventing or delaying the onset of an increase in glucose levels in an animal comprising administering to said animal a therapeutically or prophylactically effective amount of the compound of claim 1.

25 44. The method of claim 43 wherein the animal is a human.

45. The method of claim 43 wherein the glucose levels are serum glucose levels.

46. The method of claim 43 wherein the glucose levels are plasma glucose levels.

30 47. A method of modulating serum cholesterol levels in an animal comprising administering to said animal a therapeutically or prophylactically effective amount of the compound of claim 1.

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48. The method of claim 47 wherein the animal is a human.

49. A method of modulating lipoprotein levels in an
5 animal comprising administering to said animal a
therapeutically or prophylactically effective amount of
the compound of claim 1.

50. The method of claim 49 wherein the animal is a
human.

10 51. The method of claim 49 wherein the lipoprotein
is VLDL.

52. The method of claim 49 wherein the lipoprotein
is HDL.

15 53. The method of claim 49 wherein the lipoprotein
is LDL.

54. A method of modulating serum triglyceride
levels in an animal comprising administering to said
animal a therapeutically or prophylactically effective
amount of the compound of claim 1.

20 55. The method of claim 54 wherein the animal is a
human.

56. The compound of claim 1, wherein said compound
specifically hybridizes with and inhibits the expression
of a nucleic acid molecule encoding an alternatively
25 spliced form of apolipoprotein B.

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SEQUENCE LISTING

<110> Isis Pharmaceuticals, Inc.
 Rosanne M. Crooke
 Mark J. Graham

<120> ANTISENSE MODULATION OF APOLIPOPROTEIN B EXPRESSION

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<150> 10/135,985
 <151> 2002-04-30

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-2-

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-4-

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530 535 540	
gtt ctt ctt cag act ttc ctt gat gat gct tct ccg gga gat aag cga	1802
Val Leu Leu Gln Thr Phe Leu Asp Asp Ala Ser Pro Gly Asp Lys Arg	
545 550 555	
ctg gct gcc tat ctt atg ttg atg agg agt cct tca cag gca gat att	1850
Leu Ala Ala Tyr Leu Met Leu Met Arg Ser Pro Ser Gln Ala Asp Ile	
560 565 570	
aac aaa att gtc caa att cta cca tgg gaa cag aat gag caa gtg aag	1898
Asn Lys Ile Val Gln Ile Leu Pro Trp Glu Gln Asn Glu Gln Val Lys	
575 580 585 590	
aac ttt gtg gct tcc cat att gcc aat atc ttg aac tca gaa gaa ttg	1946
Asn Phe Val Ala Ser His Ile Ala Asn Ile Leu Asn Ser Glu Glu Leu	
595 600 605	
gat atc caa gat ctg aaa aag tta gtg aaa gaa gct ctg aaa gaa tct	1994
Asp Ile Gln Asp Leu Lys Lys Leu Val Lys Glu Ala Leu Lys Glu Ser	
610 615 620	
caa ctt cca act gtc atg gac ttc aga aaa ttc tct cgg aac tat caa	2042
Gln Leu Pro Thr Val Met Asp Phe Arg Lys Phe Ser Arg Asn Tyr Gln	
625 630 635	
ctc tac aaa tct gtt tct ctt cca tca ctt gac cca gcc tca gcc aaa	2090
Leu Tyr Lys Ser Val Ser Leu Pro Ser Leu Asp Pro Ala Ser Ala Lys	
640 645 650	
ata gaa ggg aat ctt ata ttt gat cca aat aac tac ctt cct aaa gaa	2138
Ile Glu Gly Asn Leu Ile Phe Asp Pro Asn Asn Tyr Leu Pro Lys Glu	
655 660 665 670	
agc atg ctg aaa act acc ctc act gcc ttt gga ttt gct tca gct gac	2186
Ser Met Leu Lys Thr Thr Leu Thr Ala Phe Gly Phe Ala Ser Ala Asp	
675 680 685	
ctc atc gag att ggc ttg gaa gga aaa ggc ttt gag cca aca ttg gaa	2234
Leu Ile Glu Ile Gly Leu Glu Gly Lys Gly Phe Glu Pro Thr Leu Glu	
690 695 700	
gct ctt ttt ggg aag caa gga ttt ttc cca gac agt gtc aac aaa gct	2282
Ala Leu Phe Gly Lys Gln Gly Phe Phe Pro Asp Ser Val Asn Lys Ala	
705 710 715	
ttg tac tgg gtt aat ggt caa gtt cct gat ggt gtc tct aag gtc tta	2330
Leu Tyr Trp Val Asn Gly Gln Val Pro Asp Gly Val Ser Lys Val Leu	
720 725 730	

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gtg gac cac ttt ggc tat acc aaa gat gat aaa cat gag cag gat atg	2378
Val Asp His Phe Gly Tyr Thr Lys Asp Asp Lys His Glu Gln Asp Met	
735 740 745 750	
gta aat gga ata atg ctc agt gtt gag aag ctg att aaa gat ttg aaa	2426
Val Asn Gly Ile Met Leu Ser Val Glu Lys Leu Ile Lys Asp Leu Lys	
755 760 765	
tcc aaa gaa gtc ccg gaa gcc aga gcc tac ctc cgc atc ttg gga gag	2474
Ser Lys Glu Val Pro Glu Ala Arg Ala Tyr Leu Arg Ile Leu Gly Glu	
770 775 780	
gag ctt ggt ttt gcc agt ctc cat gac ctc cag ctc ctg gga aag ctg	2522
Glu Leu Gly Phe Ala Ser Leu His Asp Leu Gln Leu Leu Gly Lys Leu	
785 790 795	
ctt ctg atg ggt gcc cgc act ctg cag ggg atc ccc cag atg att gga	2570
Leu Leu Met Gly Ala Arg Thr Leu Gln Gly Ile Pro Gln Met Ile Gly	
800 805 810	
gag gtc atc agg aag ggc tca aag aat gac ttt ttt ctt cac tac atc	2618
Glu Val Ile Arg Lys Gly Ser Lys Asn Asp Phe Phe Leu His Tyr Ile	
815 820 825 830	
ttc atg gag aat gcc ttt gaa ctc ccc act gga gct gga tta cag ttg	2666
Phe Met Glu Asn Phe Glu Leu Pro Thr Gly Ala Gly Leu Gln Leu	
835 840 845	
caa ata tct tca tct gga gtc att gct ccc gga gcc aag gct gga gta	2714
Gln Ile Ser Ser Ser Gly Val Ile Ala Pro Gly Ala Lys Ala Gly Val	
850 855 860	
aaa ctg gaa gta gcc aac atg cag gct gaa ctg gtg gca aaa ccc tcc	2762
Lys Leu Glu Val Ala Asn Met Gln Ala Glu Leu Val Ala Lys Pro Ser	
865 870 875	
gtg tct gtg gag ttt gtg aca aat atg ggc atc atc att ccg gac ttc	2810
Val Ser Val Glu Phe Val Thr Asn Met Gly Ile Ile Ile Pro Asp Phe	
880 885 890	
gct agg agt ggg gtc cag atg aac acc aac ttc ttc cac gag tcg ggt	2858
Ala Arg Ser Gly Val Gln Met Asn Thr Asn Phe Phe His Glu Ser Gly	
895 900 905 910	
ctg gag gct cat gtt gcc cta aaa gct ggg aag ctg aag ttt atc att	2906
Leu Glu Ala His Val Ala Leu Lys Ala Gly Lys Leu Lys Phe Ile Ile	
915 920 925	
cct tcc cca aag aga cca gtc aag ctg ctc agt gga ggc aac aca tta	2954
Pro Ser Pro Lys Arg Pro Val Lys Leu Leu Ser Gly Gly Asn Thr Leu	
930 935 940	
cat ttg gtc tct acc acc aaa acg gag gtg atc cca cct ctc att gag	3002
His Leu Val Ser Thr Thr Lys Thr Glu Val Ile Pro Pro Leu Ile Glu	
945 950 955	
aac agg cag tcc tgg tca gtt tgc aag caa gtc ttt cct ggc ctg aat	3050
Asn Arg Gln Ser Trp Ser Val Cys Lys Gln Val Phe Pro Gly Leu Asn	
960 965 970	

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tac tgc acc tca ggc gct tac tcc aac gcc agc tcc aca gac tcc gcc	3098
Tyr Cys Thr Ser Gly Ala Tyr Ser Asn Ala Ser Ser Thr Asp Ser Ala	
975 980 985 990	
tcc tac tat ccg ctg acc ggg gac acc aga tta gag ctg gaa ctg agg	3146
Ser Tyr Tyr Pro Leu Thr Gly Asp Thr Arg Leu Glu Leu Glu Leu Arg	
995 1000 1005	
cct aca gga gag att gag cag tat tct gtc agc gca acc tat gag ctc	3194
Pro Thr Gly Glu Ile Glu Gln Tyr Ser Val Ser Ala Thr Tyr Glu Leu	
1010 1015 1020	
cag aga gag gac aga gcc ttg gtg gat acc ctg aag ttt gta act caa	3242
Gln Arg Glu Asp Arg Ala Leu Val Asp Thr Leu Lys Phe Val Thr Gln	
1025 1030 1035	
gca gaa ggt gcg aag cag act gag gct acc atg aca ttc aaa tat aat	3290
Ala Glu Gly Ala Lys Gln Thr Glu Ala Thr Met Thr Phe Lys Tyr Asn	
1040 1045 1050	
cgg cag agt atg acc ttg tcc agt gaa gtc caa att ccg gat ttt gat	3338
Arg Gln Ser Met Thr Leu Ser Ser Glu Val Gln Ile Pro Asp Phe Asp	
1055 1060 1065 1070	
gtt gac ctc gga aca atc ctc aga gtt aat gat gaa tct act gag gcc	3386
Val Asp Leu Gly Thr Ile Leu Arg Val Asn Asp Glu Ser Thr Glu Gly	
1075 1080 1085	
aaa acg tct tac aga ctc acc ctg gac att cag aac aag aaa att act	3434
Lys Thr Ser Tyr Arg Leu Thr Leu Asp Ile Gln Asn Lys Lys Ile Thr	
1090 1095 1100	
gag gtc gcc ctc atg ggc cac cta agt tgt gac aca aag gaa gaa aga	3482
Glu Val Ala Leu Met Gly His Leu Ser Cys Asp Thr Lys Glu Glu Arg	
1105 1110 1115	
aaa atc aag ggt gtt att tcc ata ccc cgt ttg caa gca gaa gcc aga	3530
Lys Ile Lys Gly Val Ile Ser Ile Pro Arg Leu Gln Ala Glu Ala Arg	
1120 1125 1130	
agt gag atc ctc gcc cac tgg tcg cct gcc aaa ctg ctt ctc caa atg	3578
Ser Glu Ile Leu Ala His Trp Ser Pro Ala Lys Leu Leu Leu Gln Met	
1135 1140 1145 1150	
gac tca tct gct aca gct tat ggc tcc aca gtt tcc aag agg gtg gca	3626
Asp Ser Ser Ala Thr Ala Tyr Gly Ser Thr Val Ser Lys Arg Val Ala	
1155 1160 1165	
tgg cat tat gat gaa gag aag att gaa ttt gaa tgg aac aca ggc acc	3674
Trp His Tyr Asp Glu Glu Lys Ile Glu Phe Glu Trp Asn Thr Gly Thr	
1170 1175 1180	
aat gta gat acc aaa aaa atg act tcc aat ttc cct gtg gat ctc tcc	3722
Asn Val Asp Thr Lys Lys Met Thr Ser Asn Phe Pro Val Asp Leu Ser	
1185 1190 1195	
gat tat cct aag agc ttg cat atg tat gct aat aga ctc ctg gat cac	3770
Asp Tyr Pro Lys Ser Leu His Met Tyr Ala Asn Arg Leu Leu Asp His	
1200 1205 1210	

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aga gtc cct gaa aca gac atg act ttc cgg cac gtg ggt tcc aaa tta	3818
Arg Val Pro Glu Thr Asp Met Thr Phe Arg His Val Gly Ser Lys Leu	
1215 1220 1225 1230	
ata gtt gca atg agc tca tgg ctt cag aag gca tct ggg agt ctt cct	3866
Ile Val Ala Met Ser Ser Trp Leu Gln Lys Ala Ser Gly Ser Leu Pro	
1235 1240 1245	
tat acc cag act ttg caa gac cac ctc aat agc ctg aag gag ttc aac	3914
Tyr Thr Gln Thr Leu Gln Asp His Leu Asn Ser Leu Lys Glu Phe Asn	
1250 1255 1260	
ctc cag aac atg gga ttg cca gac ttc cac atc cca gaa aac ctc ttc	3962
Leu Gln Asn Met Gly Leu Pro Asp Phe His Ile Pro Glu Asn Leu Phe	
1265 1270 1275	
tta aaa agc gat ggc cgg gtc aaa tat acc ttg aac aag aac agt ttg	4010
Leu Lys Ser Asp Gly Arg Val Lys Tyr Thr Leu Asn Lys Asn Ser Leu	
1280 1285 1290	
aaa att gag att cct ttg cct ttt ggt ggc aaa tcc tcc aga gat cta	4058
Lys Ile Glu Ile Pro Leu Pro Phe Gly Gly Lys Ser Ser Arg Asp Leu	
1295 1300 1305 1310	
aag atg tta gag act gtt agg aca cca gcc ctc cac ttc aag tct gtg	4106
Lys Met Leu Glu Thr Val Arg Thr Pro Ala Leu His Phe Lys Ser Val	
1315 1320 1325	
gga ttc cat ctg cca tct cga gag ttc caa gtc cct act ttt acc att	4154
Gly Phe His Leu Pro Ser Arg Glu Phe Gln Val Pro Thr Phe Thr Ile	
1330 1335 1340	
ccc aag ttg tat caa ctg caa gtg cct ctc ctg ggt gtt cta gac ctc	4202
Pro Lys Leu Tyr Gln Leu Gln Val Pro Leu Leu Gly Val Leu Asp Leu	
1345 1350 1355	
tcc acg aat gtc tac agc aac ttg tac aac tgg tcc gcc tcc tac agt	4250
Ser Thr Asn Val Tyr Ser Asn Leu Tyr Asn Trp Ser Ala Ser Tyr Ser	
1360 1365 1370	
ggt ggc aac acc agc aca gac cat ttc agc ctt cgg gct cgt tac cac	4298
Gly Gly Asn Thr Ser Thr Asp His Phe Ser Leu Arg Ala Arg Tyr His	
1375 1380 1385 1390	
atg aag gct gac tct gtg gtt gac ctg ctt tcc tac aat gtg caa gga	4346
Met Lys Ala Asp Ser Val Val Asp Leu Leu Ser Tyr Asn Val Gln Gly	
1395 1400 1405	
tct gga gaa aca aca tat gac cac aag aat acg ttc aca cta tca tgt	4394
Ser Gly Glu Thr Thr Tyr Asp His Lys Asn Thr Phe Thr Leu Ser Cys	
1410 1415 1420	
gat ggg tct cta cgc cac aaa ttt cta gat tcg aat atc aaa ttc agt	4442
Asp Gly Ser Leu Arg His Lys Phe Leu Asp Ser Asn Ile Lys Phe Ser	
1425 1430 1435	
cat gta gaa aaa ctt gga aac aac cca gtc tca aaa ggt tta cta ata	4490
His Val Glu Lys Leu Gly Asn Asn Pro Val Ser Lys Gly Leu Leu Ile	
1440 1445 1450	

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ttc gat gca tct agt tcc tgg gga cca cag atg tct gct tca gtt cat	4538
Phe Asp Ala Ser Ser Ser Trp Gly Pro Gln Met Ser Ala Ser Val His	
1455 1460 1465 1470	
ttg gac tcc aaa aag aaa cag cat ttg ttt gtc aaa gaa gtc aag att	4586
Leu Asp Ser Lys Lys Lys Gln His Leu Phe Val Lys Glu Val Lys Ile	
1475 1480 1485	
gat ggg cag ttc aga gtc tct tcg ttc tat gct aaa ggc aca tat ggc	4634
Asp Gly Gln Phe Arg Val Ser Ser Phe Tyr Ala Lys Gly Thr Tyr Gly	
1490 1495 1500	
ctg tct tgt cag agg gat cct aac act ggc cgg ctc aat gga gag tcc	4682
Leu Ser Cys Gln Arg Asp Pro Asn Thr Gly Arg Leu Asn Gly Glu Ser	
1505 1510 1515	
aac ctg agg ttt aac tcc tcc tac ctc caa ggc acc aac cag ata aca	4730
Asn Leu Arg Phe Asn Ser Ser Tyr Leu Gln Gly Thr Asn Gln Ile Thr	
1520 1525 1530	
gga aga tat gaa gat gga acc ctc tcc ctc acc tcc acc tct gat ctg	4778
Gly Arg Tyr Glu Asp Gly Thr Leu Ser Leu Thr Ser Thr Ser Asp Leu	
1535 1540 1545 1550	
caa agt ggc atc att aaa aat act gct tcc cta aag tat gag aac tac	4826
Gln Ser Gly Ile Ile Lys Asn Thr Ala Ser Leu Lys Tyr Glu Asn Tyr	
1555 1560 1565	
gag ctg act tta aaa tct gac acc aat ggg aag tat aag aac ttt gcc	4874
Glu Leu Thr Leu Lys Ser Asp Thr Asn Gly Lys Tyr Lys Asn Phe Ala	
1570 1575 1580	
act tct aac aag atg gat atg acc ttc tct aag caa aat gca ctg ctg	4922
Thr Ser Asn Lys Met Asp Met Thr Phe Ser Lys Gln Asn Ala Leu Leu	
1585 1590 1595	
cgt tct gaa tat cag gct gat tac gag tca ttg agg ttc ttc agc ctg	4970
Arg Ser Glu Tyr Gln Ala Asp Tyr Glu Ser Leu Arg Phe Phe Ser Leu	
1600 1605 1610	
ctt tct gga tca cta aat tcc cat ggt ctt gag tta aat gct gac atc	5018
Leu Ser Gly Ser Leu Asn Ser His Gly Leu Glu Leu Asn Ala Asp Ile	
1615 1620 1625 1630	
tta ggc act gac aaa att aat agt ggt gct cac aag gcg aca cta agg	5066
Leu Gly Thr Asp Lys Ile Asn Ser Gly Ala His Lys Ala Thr Leu Arg	
1635 1640 1645	
att ggc caa gat gga ata tct acc agt gca acg acc aac ttg aag tgt	5114
Ile Gly Gln Asp Gly Ile Ser Thr Ser Ala Thr Thr Asn Leu Lys Cys	
1650 1655 1660	
agt ctc ctg gtg ctg gag aat gag ctg aat gca gag ctt ggc ctc tct	5162
Ser Leu Leu Val Leu Glu Asn Glu Leu Asn Ala Glu Leu Gly Leu Ser	
1665 1670 1675	
ggg gca tct atg aaa tta aca aca aat ggc cgc ttc agg gaa cac aat	5210
Gly Ala Ser Met Lys Leu Thr Thr Asn Gly Arg Phe Arg Glu His Asn	
1680 1685 1690	

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gca	aaa	ttc	agt	ctg	gat	ggg	aaa	gcc	ctc	aca	gag	cta	tca	ctg		5258
Ala	Lys	Phe	Ser	Leu	Asp	Gly	Lys	Ala	Ala	Leu	Thr	Glu	Leu	Ser	Leu	
1695					1700				1705						1710	
gga	agt	gct	tat	cag	gcc	atg	att	ctg	ggg	gtc	gac	agc	aaa	aac	att	5306
Gly	Ser	Ala	Tyr	Gln	Ala	Met	Ile	Leu	Gly	Val	Asp	Ser	Lys	Asn	Ile	
				1715					1720					1725		
ttc	aac	ttc	aag	gtc	agt	caa	gaa	gga	ctt	aag	ctc	tca	aat	gac	atg	5354
Phe	Asn	Phe	Lys	Val	Ser	Gln	Glu	Gly	Leu	Lys	Leu	Ser	Asn	Asp	Met	
			1730					1735					1740			
atg	ggc	tca	tat	gct	gaa	atg	aaa	ttt	gac	cac	aca	aac	agt	ctg	aac	5402
Met	Gly	Ser	Tyr	Ala	Glu	Met	Lys	Phe	Asp	His	Thr	Asn	Ser	Leu	Asn	
		1745					1750					1755				
att	gca	ggc	tta	tca	ctg	gac	ttc	tct	tca	aaa	ctt	gac	aac	att	tac	5450
Ile	Ala	Gly	Leu	Ser	Leu	Asp	Phe	Ser	Ser	Lys	Leu	Asp	Asn	Ile	Tyr	
	1760					1765					1770					
agc	tct	gac	aag	ttt	tat	aag	caa	act	gtt	aat	tta	cag	cta	cag	ccc	5498
Ser	Ser	Asp	Lys	Phe	Tyr	Lys	Gln	Thr	Val	Asn	Leu	Gln	Leu	Gln	Pro	
1775				1780					1785						1790	
tat	tct	ctg	gta	act	act	tta	aac	agt	gac	ctg	aaa	tac	aat	gct	ctg	5546
Tyr	Ser	Leu	Val	Thr	Thr	Leu	Asn	Ser	Asp	Leu	Lys	Tyr	Asn	Ala	Leu	
			1795						1800					1805		
gat	ctc	acc	aac	aat	ggg	aaa	cta	cgg	cta	gaa	ccc	ctg	aag	ctg	cat	5594
Asp	Leu	Thr	Asn	Asn	Gly	Lys	Leu	Arg	Leu	Glu	Pro	Leu	Lys	Leu	His	
			1810					1815				1820				
gtg	gct	ggg	aac	cta	aaa	gga	gcc	tac	caa	aat	aat	gaa	ata	aaa	cac	5642
Val	Ala	Gly	Asn	Leu	Lys	Gly	Ala	Tyr	Gln	Asn	Asn	Glu	Ile	Lys	His	
		1825					1830					1835				
atc	tat	gcc	atc	tct	tct	gct	gcc	tta	tca	gca	agc	tat	aaa	gca	gac	5690
Ile	Tyr	Ala	Ile	Ser	Ser	Ala	Ala	Leu	Ser	Ala	Ser	Tyr	Lys	Ala	Asp	
		1840				1845					1850					
act	gtt	gct	aag	gtt	cag	ggg	gtg	gag	ttt	agc	cat	cgg	ctc	aac	aca	5738
Thr	Val	Ala	Lys	Val	Gln	Gly	Val	Glu	Phe	Ser	His	Arg	Leu	Asn	Thr	
1855				1860					1865						1870	
gac	atc	gct	ggg	ctg	gct	tca	gcc	att	gac	atg	agc	aca	aac	tat	aat	5786
Asp	Ile	Ala	Gly	Leu	Ala	Ser	Ala	Ile	Asp	Met	Ser	Thr	Asn	Tyr	Asn	
			1875						1880					1885		
tca	gac	tca	ctg	cat	ttc	agc	aat	gtc	ttc	cgt	tct	gta	atg	gcc	ccg	5834
Ser	Asp	Ser	Leu	His	Phe	Ser	Asn	Val	Phe	Arg	Ser	Val	Met	Ala	Pro	
			1890					1895				1900				
ttt																

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gca gaa cct ctg gca ttt act ttc tct cat gat tac aaa ggc tcc aca	5978
Ala Glu Pro Leu Ala Phe Thr Phe Ser His Asp Tyr Lys Gly Ser Thr	
1935 1940 1945 1950	
agt cat cat ctc gtg tct agg aaa agc atc agt gca gct ctt gaa cac	6026
Ser His His Leu Val Ser Arg Lys Ser Ile Ser Ala Ala Leu Glu His	
1955 1960 1965	
aaa gtc agt gcc ctg ctt act cca gct gag cag aca ggc acc tgg aaa	6074
Lys Val Ser Thr Ala Leu Leu Thr Pro Ala Glu Gln Thr Gly Thr Trp Lys	
1970 1975 1980	
ctc aag acc caa ttt aac aac aat gaa tac agc cag gac ttg gat gct	6122
Leu Lys Thr Gln Phe Asn Asn Asn Glu Tyr Ser Gln Asp Leu Asp Ala	
1985 1990 1995	
tac aac act aaa gat aaa att ggc gtg gag ctt act gga cga act ctg	6170
Tyr Asn Thr Lys Asp Lys Ile Gly Val Glu Leu Thr Gly Arg Thr Leu	
2000 2005 2010	
gct gac cta act cta cta gac tcc cca att aaa gtg cca ctt tta ctc	6218
Ala Asp Leu Thr Leu Leu Asp Ser Pro Ile Lys Val Pro Leu Leu Leu	
2015 2020 2025 2030	
agt gag ccc atc aat atc att gat gct tta gag atg aga gat gcc gtt	6266
Ser Glu Pro Ile Asn Ile Ile Asp Ala Leu Glu Met Arg Asp Ala Val	
2035 2040 2045	
gag aag ccc caa gaa ttt aca att gtt gct ttt gta aag tat gat aaa	6314
Glu Lys Pro Gln Glu Phe Thr Ile Val Ala Phe Val Lys Tyr Asp Lys	
2050 2055 2060	
aac caa gat gtt cac tcc att aac ctc cca ttt ttt gag acc ttg caa	6362
Asn Gln Asp Val His Ser Ile Asn Leu Pro Phe Phe Glu Thr Leu Gln	
2065 2070 2075	
gaa tat ttt gag agg aat cga caa acc att ata gtt gta gtg gaa aac	6410
Glu Tyr Phe Glu Arg Asn Arg Gln Thr Ile Ile Val Val Val Glu Asn	
2080 2085 2090	
gta cag aga aac ctg aag cac atc aat att gat caa ttt gta aga aaa	6458
Val Gln Arg Asn Leu Lys His Ile Asn Ile Asp Gln Phe Val Arg Lys	
2095 2100 2105 2110	
tac aga gca gcc ctg gga aaa ctc cca cag caa gct aat gat tat ctg	6506
Tyr Arg Ala Ala Leu Gly Lys Leu Pro Gln Gln Ala Asn Asp Tyr Leu	
2115 2120 2125	
aat tca ttc aat tgg gag aga caa gtt tca cat gcc aag gag aaa ctg	6554
Asn Ser Phe Asn Trp Glu Arg Gln Val Ser His Ala Lys Glu Lys Leu	
2130 2135 2140	
act gct ctc aca aaa aag tat aga att aca gaa aat gat ata caa att	6602
Thr Ala Leu Thr Lys Lys Tyr Arg Ile Thr Glu Asn Asp Ile Gln Ile	
2145 2150 2155	
gca tta gat gat gcc aaa atc aac ttt aat gaa aaa cta tct caa ctg	6650
Ala Leu Asp Asp Ala Lys Ile Asn Phe Asn Glu Lys Leu Ser Gln Leu	
2160 2165 2170	

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cag aca tat atg ata caa ttt gat cag tat att aaa gat agt tat gat	6698
Gln Thr Tyr Met Ile Gln Phe Asp Gln Tyr Ile Lys Asp Ser Tyr Asp	
2175 2180 2185 2190	
tta cat gat ttg aaa ata gct att gct aat att att gat gaa atc att	6746
Leu His Asp Leu Lys Ile Ala Ile Ala Asn Ile Ile Asp Glu Ile Ile	
2195 2200 2205	
gaa aaa tta aaa agt ctt gat gag cac tat cat atc cgt gta aat tta	6794
Glu Lys Leu Lys Ser Leu Asp Glu His Tyr His Ile Arg Val Asn Leu	
2210 2215 2220	
gta aaa aca atc cat gat cta cat ttg ttt att gaa aat att gat ttt	6842
Val Lys Thr Ile His Asp Leu His Leu Phe Ile Glu Asn Ile Asp Phe	
2225 2230 2235	
aac aaa agt gga agt agt act gca tcc tgg att caa aat gtg gat act	6890
Asn Lys Ser Gly Ser Ser Thr Ala Ser Trp Ile Gln Asn Val Asp Thr	
2240 2245 2250	
aag tac caa atc aga atc cag ata caa gaa aaa ctg cag cag ctt aag	6938
Lys Tyr Gln Ile Arg Ile Gln Ile Gln Glu Lys Leu Gln Gln Leu Lys	
2255 2260 2265 2270	
aga cac ata cag aat ata gac atc cag cac cta gct gga aag tta aaa	6986
Arg His Ile Gln Asn Ile Asp Ile Gln His Leu Ala Gly Lys Leu Lys	
2275 2280 2285	
caa cac att gag gct att gat gtt aga gtg ctt tta gat caa ttg gga	7034
Gln His Ile Glu Ala Ile Asp Val Arg Val Leu Leu Asp Gln Leu Gly	
2290 2295 2300	
act aca att tca ttt gaa aga ata aat gat gtt ctt gag cat gtc aaa	7082
Thr Thr Ile Ser Phe Glu Arg Ile Asn Asp Val Leu Glu His Val Lys	
2305 2310 2315	
cac ttt gtt ata aat ctt att ggg gat ttt gaa gta gct gag aaa atc	7130
His Phe Val Ile Asn Leu Ile Gly Asp Phe Glu Val Ala Glu Lys Ile	
2320 2325 2330	
aat gcc ttc aga gcc aaa gtc cat gag tta atc gag agg tat gaa gta	7178
Asn Ala Phe Arg Ala Lys Val His Glu Leu Ile Glu Arg Tyr Glu Val	
2335 2340 2345 2350	
gac caa caa atc cag gtt tta atg gat aaa tta gta gag ttg acc cac	7226
Asp Gln Gln Ile Gln Val Leu Met Asp Lys Leu Val Glu Leu Thr His	
2355 2360 2365	
caa tac aag ttg aag gag act att cag aag cta agc aat gtc cta caa	7274
Gln Tyr Lys Leu Lys Glu Thr Ile Gln Lys Leu Ser Asn Val Leu Gln	
2370 2375 2380	
caa gtt aag ata aaa gat tac ttt gag aaa ttg gtt gga ttt att gat	7322
Gln Val Lys Ile Lys Asp Tyr Phe Glu Lys Leu Val Gly Phe Ile Asp	
2385 2390 2395	
gat gct gtg aag aag ctt aat gaa tta tct ttt aaa aca ttc att gaa	7370
Asp Ala Val Lys Lys Leu Asn Glu Leu Ser Phe Lys Thr Phe Ile Glu	
2400 2405 2410	

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gat gtt aac aaa ttc ctt gac atg ttg ata aag aaa tta aag tca ttt	7418
Asp Val Asn Lys Phe Leu Asp Met Leu Ile Lys Lys Leu Lys Ser Phe	
2415 2420 2425 2430	
gat tac cac cag ttt gta gat gaa acc aat gac aaa atc cgt gag gtg	7466
Asp Tyr His Gln Phe Val Asp Glu Thr Asn Asp Lys Ile Arg Glu Val	
2435 2440 2445	
act cag aga ctc aat ggt gaa att cag gct ctg gaa cta cca caa aaa	7514
Thr Gln Arg Leu Asn Gly Glu Ile Gln Ala Leu Glu Leu Pro Gln Lys	
2450 2455 2460	
gct gaa gca tta aaa ctg ttt tta gag gaa acc aag gcc aca gtt gca	7562
Ala Glu Ala Leu Lys Leu Phe Leu Glu Glu Thr Lys Ala Thr Val Ala	
2465 2470 2475	
gtg tat ctg gaa agc cta cag gac acc aaa ata acc tta atc atc aat	7610
Val Tyr Leu Glu Ser Leu Gln Asp Thr Lys Ile Thr Leu Ile Ile Asn	
2480 2485 2490	
tgg tta cag gag gct tta agt tca gca tct ttg gct cac atg aag gcc	7658
Trp Leu Gln Glu Ala Leu Ser Ser Ala Ser Leu Ala His Met Lys Ala	
2495 2500 2505 2510	
aaa ttc cga gag act cta gaa gat aca cga gac cga atg tat caa atg	7706
Lys Phe Arg Glu Thr Leu Glu Asp Thr Arg Asp Arg Met Tyr Gln Met	
2515 2520 2525	
gac att cag cag gaa ctt caa cga tac ctg tct ctg gta ggc cag gtt	7754
Asp Ile Gln Gln Glu Leu Gln Arg Tyr Leu Ser Leu Val Gly Gln Val	
2530 2535 2540	
tat agc aca ctt gtc acc tac att tct gat tgg tgg act ctt gct gct	7802
Tyr Ser Thr Leu Val Thr Tyr Ile Ser Asp Trp Trp Thr Leu Ala Ala	
2545 2550 2555	
aag aac ctt act gac ttt gca gag caa tat tct atc caa gat tgg gct	7850
Lys Asn Leu Thr Asp Phe Ala Glu Gln Tyr Ser Ile Gln Asp Trp Ala	
2560 2565 2570	
aaa cgt atg aaa gca ttg gta gag caa ggg ttc act gtt cct gaa atc	7898
Lys Arg Met Lys Ala Leu Val Glu Gln Gly Phe Thr Val Pro Glu Ile	
2575 2580 2585 2590	
aag acc atc ctt ggg acc atg cct gcc ttt gaa gtc agt ctt cag gct	7946
Lys Thr Ile Leu Gly Thr Met Pro Ala Phe Glu Val Ser Leu Gln Ala	
2595 2600 2605	
ctt cag aaa gct acc ttc cag aca cct gat ttt ata gtc ccc cta aca	7994
Leu Gln Lys Ala Thr Phe Gln Thr Pro Asp Phe Ile Val Pro Leu Thr	
2610 2615 2620	
gat ttg agg att cca tca gtt cag ata aac ttc aaa gac tta aaa aat	8042
Asp Leu Arg Ile Pro Ser Val Gln Ile Asn Phe Lys Asp Leu Lys Asn	
2625 2630 2635	
ata aaa atc cca tcc agg ttt tcc aca cca gaa ttt acc atc ctt aac	8090
Ile Lys Ile Pro Ser Arg Phe Ser Thr Pro Glu Phe Thr Ile Leu Asn	
2640 2645 2650	

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acc ttc cac att cct tcc ttt aca att gac ttt gtc gaa atg aaa gta	8138
Thr Phe His Ile Pro Ser Phe Thr Ile Asp Phe Val Glu Met Lys Val	
2655 2660 2665 2670	
aag atc atc aga acc att gac cag atg cag aac agt gag ctg cag tgg	8186
Lys Ile Ile Arg Thr Ile Asp Gln Met Gln Asn Ser Glu Leu Gln Trp	
2675 2680 2685	
ccc gtt cca gat ata tat ctc agg gat ctg aag gtg gag gac att cct	8234
Pro Val Pro Asp Ile Tyr Leu Arg Asp Leu Lys Val Glu Asp Ile Pro	
2690 2695 2700	
cta gcg aga atc acc ctg cca gac ttc cgt tta cca gaa atc gca att	8282
Leu Ala Arg Ile Thr Leu Pro Asp Phe Arg Leu Pro Glu Ile Ala Ile	
2705 2710 2715	
cca gaa ttc ata atc cca act ctc aac ctt aat gat ttt caa gtt cct	8330
Pro Glu Phe Ile Ile Pro Thr Leu Asn Leu Asn Asp Phe Gln Val Pro	
2720 2725 2730	
gac ctt cac ata cca gaa ttc cag ctt ccc cac atc tca cac aca att	8378
Asp Leu His Ile Pro Glu Phe Gln Leu Pro His Ile Ser His Thr Ile	
2735 2740 2745 2750	
gaa gta cct act ttt ggc aag cta tac agt att ctg aaa atc caa tct	8426
Glu Val Pro Thr Phe Gly Lys Leu Tyr Ser Ile Leu Lys Ile Gln Ser	
2755 2760 2765	
cct ctt ttc aca tta gat gca aat gct gac ata ggg aat gga acc acc	8474
Pro Leu Phe Thr Leu Asp Ala Asn Ala Asp Ile Gly Asn Gly Thr Thr	
2770 2775 2780	
tca gca aac gaa gca ggt atc gca gct tcc atc act gcc aaa gga gag	8522
Ser Ala Asn Glu Ala Gly Ile Ala Ala Ser Ile Thr Ala Lys Gly Glu	
2785 2790 2795	
tcc aaa tta gaa gtt ctc aat ttt gat ttt caa gca aat gca caa ctc	8570
Ser Lys Leu Glu Val Leu Asn Phe Asp Phe Gln Ala Asn Ala Gln Leu	
2800 2805 2810	
tca aac cct aag att aat ccg ctg gct ctg aag gag tca gtg aag ttc	8618
Ser Asn Pro Lys Ile Asn Pro Leu Ala Leu Lys Glu Ser Val Lys Phe	
2815 2820 2825 2830	
tcc agc aag tac ctg aga acg gag cat ggg agt gaa atg ctg ttt ttt	8666
Ser Ser Lys Tyr Leu Arg Thr Glu His Gly Ser Glu Met Leu Phe Phe	
2835 2840 2845	
gga aat gct att gag gga aaa tca aac aca gtg gca agt tta cac aca	8714
Gly Asn Ala Ile Glu Gly Lys Ser Asn Thr Val Ala Ser Leu His Thr	
2850 2855 2860	
gaa aaa aat aca ctg gag ctt agt aat gga gtg att gtc aag ata aac	8762
Glu Lys Asn Thr Leu Glu Leu Ser Asn Gly Val Ile Val Lys Ile Asn	
2865 2870 2875	
aat cag ctt acc ctg gat agc aac act aaa tac ttc cac aaa ttg aac	8810
Asn Gln Leu Thr Leu Asp Ser Asn Thr Lys Tyr Phe His Lys Leu Asn	
2880 2885 2890	

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atc ccc aaa ctg gac ttc tct agt cag gct gac ctg cgc aac gag atc	8858
Ile Pro Lys Leu Asp Phe Ser Ser Gln Ala Asp Leu Arg Asn Glu Ile	
2895 2900 2905 2910	
aag aca ctg ttg aaa gct ggc cac ata gca tgg act tct tct gga aaa	8906
Lys Thr Leu Leu Lys Ala Gly His Ile Ala Trp Thr Ser Ser Gly Lys	
2915 2920 2925	
ggg tca tgg aaa tgg gcc tgc ccc aga ttc tca gat gag gga aca cat	8954
Gly Ser Trp Lys Trp Ala Cys Pro Arg Phe Ser Asp Glu Gly Thr His	
2930 2935 2940	
gaa tca caa att agt ttc acc ata gaa gga ccc ctc act tcc ttt gga	9002
Glu Ser Gln Ile Ser Phe Thr Ile Glu Gly Pro Leu Thr Ser Phe Gly	
2945 2950 2955	
ctg tcc aat aag atc aat agc aaa cac cta aga gta aac caa aac ttg	9050
Leu Ser Asn Lys Ile Asn Ser Lys His Leu Arg Val Asn Gln Asn Leu	
2960 2965 2970	
gtt tat gaa tct ggc tcc ctc aac ttt tct aaa ctt gaa att caa tca	9098
Val Tyr Glu Ser Gly Ser Leu Asn Phe Ser Lys Leu Glu Ile Gln Ser	
2975 2980 2985 2990	
caa gtc gat tcc cag cat gtg ggc cac agt gtt cta act gct aaa ggc	9146
Gln Val Asp Ser Gln His Val Gly His Ser Val Leu Thr Ala Lys Gly	
2995 3000 3005	
atg gca ctg ttt gga gaa ggg aag gca gag ttt act ggg agg cat gat	9194
Met Ala Leu Phe Gly Glu Gly Lys Ala Glu Phe Thr Gly Arg His Asp	
3010 3015 3020	
gct cat tta aat gga aag gtt att gga act ttg aaa aat tct ctt ttc	9242
Ala His Leu Asn Gly Lys Val Ile Gly Thr Leu Lys Asn Ser Leu Phe	
3025 3030 3035	
ttt tca gcc cag cca ttt gag atc acg gca tcc aca aac aat gaa ggg	9290
Phe Ser Ala Gln Pro Phe Glu Ile Thr Ala Ser Thr Asn Asn Glu Gly	
3040 3045 3050	
aat ttg aaa gtt cgt ttt cca tta agg tta aca ggg aag ata gac ttc	9338
Asn Leu Lys Val Arg Phe Pro Leu Arg Leu Thr Gly Lys Ile Asp Phe	
3055 3060 3065 3070	
ctg aat aac tat gca ctg ttt ctg agt ccc agt gcc cag caa gca agt	9386
Leu Asn Asn Tyr Ala Leu Phe Leu Ser Pro Ser Ala Gln Gln Ala Ser	
3075 3080 3085	
tgg caa gta agt gct agg ttc aat cag tat aag tac aac caa aat ttc	9434
Trp Gln Val Ser Ala Arg Phe Asn Gln Tyr Lys Tyr Asn Gln Asn Phe	
3090 3095 3100	
tct gct gga aac aac gag aac att atg gag gcc cat gta gga ata aat	9482
Ser Ala Gly Asn Asn Glu Asn Ile Met Glu Ala His Val Gly Ile Asn	
3105 3110 3115	
gga gaa gca aat ctg gat ttc tta aac att cct tta aca att cct gaa	9530
Gly Glu Ala Asn Leu Asp Phe Leu Asn Ile Pro Leu Thr Ile Pro Glu	
3120 3125 3130	

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atg cgt cta cct tac aca ata atc aca act cct cca ctg aaa gat ttc	9578
Met Arg Leu Pro Tyr Thr Ile Ile Thr Thr Pro Pro Leu Lys Asp Phe	
3135 3140 3145 3150	
tct cta tgg gaa aaa aca ggc ttg aag gaa ttc ttg aaa acg aca aag	9626
Ser Leu Trp Glu Lys Thr Gly Leu Lys Glu Phe Leu Lys Thr Thr Lys	
3155 3160 3165	
caa tca ttt gat tta agt gta aaa gct cag tat aag aaa aac aaa cac	9674
Gln Ser Phe Asp Leu Ser Val Lys Ala Gln Tyr Lys Lys Asn Lys His	
3170 3175 3180	
agg cat tcc atc aca aat cct ttg gct gtg ctt tgt gag ttt atc agt	9722
Arg His Ser Ile Thr Asn Pro Leu Ala Val Leu Cys Glu Phe Ile Ser	
3185 3190 3195	
cag agc atc aaa tcc ttt gac agg cat ttt gaa aaa aac aga aac aat	9770
Gln Ser Ile Lys Ser Phe Asp Arg His Phe Glu Lys Asn Arg Asn Asn	
3200 3205 3210	
gca tta gat ttt gtc acc aaa tcc tat aat gaa aca aaa att aag ttt	9818
Ala Leu Asp Phe Val Thr Lys Ser Tyr Asn Glu Thr Lys Ile Lys Phe	
3215 3220 3225 3230	
gat aag tac aaa gct gaa aaa tct cac gac gag ctc ccc agg acc ttt	9866
Asp Lys Tyr Lys Ala Glu Lys Ser His Asp Glu Leu Pro Arg Thr Phe	
3235 3240 3245	
caa att cct gga tac act gtt cca gtt gtc aat gtt gaa gtg tct cca	9914
Gln Ile Pro Gly Tyr Thr Val Pro Val Val Asn Val Glu Val Ser Pro	
3250 3255 3260	
ttc acc ata gag atg tcg gca ttc ggc tat gtg ttc cca aaa gca gtc	9962
Phe Thr Ile Glu Met Ser Ala Phe Gly Tyr Val Phe Pro Lys Ala Val	
3265 3270 3275	
agc atg cct agt ttc tcc atc cta ggt tct gac gtc cgt gtg cct tca	10010
Ser Met Pro Ser Phe Ser Ile Leu Gly Ser Asp Val Arg Val Pro Ser	
3280 3285 3290	
tac aca tta atc ctg cca tca tta gag ctg cca gtc ctt cat gtc cct	10058
Tyr Thr Leu Ile Leu Pro Ser Leu Glu Leu Pro Val Leu His Val Pro	
3295 3300 3305 3310	
aga aat ctc aag ctt tct ctt cca cat ttc aag gaa ttg tgt acc ata	10106
Arg Asn Leu Lys Leu Ser Leu Pro His Phe Lys Glu Leu Cys Thr Ile	
3315 3320 3325	
agc cat att ttt att cct gcc atg ggc aat att acc tat gat ttc tcc	10154
Ser His Ile Phe Ile Pro Ala Met Gly Asn Ile Thr Tyr Asp Phe Ser	
3330 3335 3340	
ttt aaa tca agt gtc atc aca ctg aat acc aat gct gaa ctt ttt aac	10202
Phe Lys Ser Ser Val Ile Thr Leu Asn Thr Asn Ala Glu Leu Phe Asn	
3345 3350 3355	
cag tca gat att gtt gct cat ctc ctt tct tca tct tca tct gtc att	10250
Gln Ser Asp Ile Val Ala His Leu Leu Ser Ser Ser Ser Ser Val Ile	
3360 3365 3370	

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gat gca ctg cag tac aaa tta gag ggc acc aca aga ttg aca aga aaa Asp Ala Leu Gln Tyr Lys Leu Glu Gly Thr Thr Arg Leu Thr Arg Lys 3375 3380 3385 3390	10298
agg gga ttg aag tta gcc aca gct ctg tct ctg agc aac aaa ttt gtg Arg Gly Leu Lys Leu Ala Thr Ala Leu Ser Leu Ser Asn Lys Phe Val 3395 3400 3405	10346
gag ggt agt cat aac agt act gtg agc tta acc acg aaa aat atg gaa Glu Gly Ser His Asn Ser Thr Val Ser Leu Thr Thr Lys Asn Met Glu 3410 3415 3420	10394
gtg tca gtg gca aaa acc aca aaa gcc gaa att cca att ttg aga atg Val Ser Val Ala Lys Thr Thr Lys Ala Glu Ile Pro Ile Leu Arg Met 3425 3430 3435	10442
aat ttc aag caa gaa ctt aat gga aat acc aag tca aaa cct act gtc Asn Phe Lys Gln Glu Leu Asn Gly Asn Thr Lys Ser Lys Pro Thr Val 3440 3445 3450	10490
tct tcc tcc atg gaa ttt aag tat gat ttc aat tct tca atg ctg tac Ser Ser Ser Met Glu Phe Lys Tyr Asp Phe Asn Ser Ser Met Leu Tyr 3455 3460 3465 3470	10538
tct acc gct aaa gga gca gtt gac cac aag ctt agc ttg gaa agc ctc Ser Thr Ala Lys Gly Ala Val Asp His Lys Leu Ser Leu Glu Ser Leu 3475 3480 3485	10586
acc tct tac ttt tcc att gag tca tct acc aaa gga gat gtc aag ggt Thr Ser Tyr Phe Ser Ile Glu Ser Ser Thr Lys Gly Asp Val Lys Gly 3490 3495 3500	10634
tcg gtt ctt tct cgg gaa tat tca gga act att gct agt gag gcc aac Ser Val Leu Ser Arg Glu Tyr Ser Gly Thr Ile Ala Ser Glu Ala Asn 3505 3510 3515	10682
act tac ttg aat tcc aag agc aca cgg tct tca gtg aag ctg cag ggc Thr Tyr Leu Asn Ser Lys Ser Thr Arg Ser Ser Val Lys Leu Gln Gly 3520 3525 3530	10730
act tcc aaa att gat gat atc tgg aac ctt gaa gta aaa gaa aat ttt Thr Ser Lys Ile Asp Asp Ile Trp Asn Leu Glu Val Lys Glu Asn Phe 3535 3540 3545 3550	10778
gct gga gaa gcc aca ctc caa cgc ata tat tcc ctc tgg gag cac agt Ala Gly Glu Ala Thr Leu Gln Arg Ile Tyr Ser Leu Trp Glu His Ser 3555 3560 3565	10826
acg aaa aac cac tta cag cta gag ggc ctc ttt ttc acc aac gga gaa Thr Lys Asn His Leu Gln Leu Glu Gly Leu Phe Phe Thr Asn Gly Glu 3570 3575 3580	10874
cat aca agc aaa gcc acc ctg gaa ctc tct cca tgg caa atg tca gct His Thr Ser Lys Ala Thr Leu Glu Leu Ser Pro Trp Gln Met Ser Ala 3585 3590 3595	10922
ctt gtt cag gtc cat gca agt cag ccc agt tcc ttc cat gat ttc cct Leu Val Gln Val His Ala Ser Gln Pro Ser Ser Phe His Asp Phe Pro 3600 3605 3610	10970

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gac ctt ggc cag gaa gtg gcc ctg aat gct aac act aag aac cag aag	11018
Asp Leu Gly Gln Glu Val Ala Leu Asn Ala Asn Thr Lys Asn Gln Lys	
3615 3620 3625 3630	
atc aga tgg aaa aat gaa gtc cgg att cat tct ggg tct ttc cag agc	11066
Ile Arg Trp Lys Asn Glu Val Arg Ile His Ser Gly Ser Phe Gln Ser	
3635 3640 3645	
cag gtc gag ctt tcc aat gac caa gaa aag gca cac ctt gac att gca	11114
Gln Val Glu Leu Ser Asn Asp Gln Glu Lys Ala His Leu Asp Ile Ala	
3650 3655 3660	
gga tcc tta gaa gga cac cta agg ttc ctc aaa aat atc atc cta cca	11162
Gly Ser Leu Glu Gly His Leu Arg Phe Leu Lys Asn Ile Ile Leu Pro	
3665 3670 3675	
gtc tat gac aag agc tta tgg gat ttc cta aag ctg gat gta acc acc	11210
Val Tyr Asp Lys Ser Leu Trp Asp Phe Leu Lys Leu Asp Val Thr Thr	
3680 3685 3690	
agc att ggt agg aga cag cat ctt cgt gtt tca act gcc ttt gtg tac	11258
Ser Ile Gly Arg Arg Gln His Leu Arg Val Ser Thr Ala Phe Val Tyr	
3695 3700 3705 3710	
acc aaa aac ccc aat ggc tat tca ttc tcc atc cct gta aaa gtt ttg	11306
Thr Lys Asn Pro Asn Gly Tyr Ser Phe Ser Ile Pro Val Lys Val Leu	
3715 3720 3725	
gct gat aaa ttc att act cct ggg ctg aaa cta aat gat cta aat tca	11354
Ala Asp Lys Phe Ile Thr Pro Gly Leu Lys Leu Asn Asp Leu Asn Ser	
3730 3735 3740	
gtt ctt gtc atg cct acg ttc cat gtc cca ttt aca gat ctt cag gtt	11402
Val Leu Val Met Pro Thr Phe His Val Pro Phe Thr Asp Leu Gln Val	
3745 3750 3755	
cca tcg tgc aaa ctt gac ttc aga gaa ata caa atc tat aag aag ctg	11450
Pro Ser Cys Lys Leu Asp Phe Arg Glu Ile Gln Ile Tyr Lys Lys Leu	
3760 3765 3770	
aga act tca tca ttt gcc ctc aac cta cca aca ctc ccc gag gta aaa	11498
Arg Thr Ser Ser Phe Ala Leu Asn Leu Pro Thr Leu Pro Glu Val Lys	
3775 3780 3785 3790	
ttc cct gaa gtt gat gtg tta aca aaa tat tct caa cca gaa gac tcc	11546
Phe Pro Glu Val Asp Val Leu Thr Lys Tyr Ser Gln Pro Glu Asp Ser	
3795 3800 3805	
ttg att ccc ttt ttt gag ata acc gtg cct gaa tct cag tta act gtg	11594
Leu Ile Pro Phe Phe Glu Ile Thr Val Pro Glu Ser Gln Leu Thr Val	
3810 3815 3820	
tcc cag ttc acg ctt cca aaa agt gtt tca gat ggc att gct gct ttg	11642
Ser Gln Phe Thr Leu Pro Lys Ser Val Ser Asp Gly Ile Ala Ala Leu	
3825 3830 3835	
gat cta aat gca gta gcc aac aag atc gca gac ttt gag ttg ccc acc	11690
Asp Leu Asn Ala Val Ala Asn Lys Ile Ala Asp Phe Glu Leu Pro Thr	
3840 3845 3850	

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atc atc gtg cct gag cag acc att gag att ccc tcc att aag ttc tct	11738
Ile Ile Val Pro Glu Gln Thr Ile Glu Ile Pro Ser Ile Lys Phe Ser	
3855 3860 3865 3870	
gta cct gct gga att gtc att cct tcc ttt caa gca ctg act gca cgc	11786
Val Pro Ala Gly Ile Val Ile Pro Ser Phe Gln Ala Leu Thr Ala Arg	
3875 3880 3885	
ttt gag gta gac tct ccc gtg tat aat gcc act tgg agt gcc agt ttg	11834
Phe Glu Val Asp Ser Pro Val Tyr Asn Ala Thr Trp Ser Ala Ser Leu	
3890 3895 3900	
aaa aac aaa gca gat tat gtt gaa aca gtc ctg gat tcc aca tgc agc	11882
Lys Asn Lys Ala Asp Tyr Val Glu Thr Val Leu Asp Ser Thr Cys Ser	
3905 3910 3915	
tca acc gta cag ttc cta gaa tat gaa cta aat gtt ttg gga aca cac	11930
Ser Thr Val Gln Phe Leu Glu Tyr Glu Leu Asn Val Leu Gly Thr His	
3920 3925 3930	
aaa atc gaa gat ggt acg tta gcc tct aag act aaa gga aca ctt gca	11978
Lys Ile Glu Asp Gly Thr Leu Ala Ser Lys Thr Lys Gly Thr Leu Ala	
3935 3940 3945 3950	
cac cgt gac ttc agt gca gaa tat gaa gaa gat ggc aaa ttt gaa gga	12026
His Arg Asp Phe Ser Ala Glu Tyr Glu Glu Asp Gly Lys Phe Glu Gly	
3955 3960 3965	
ctt cag gaa tgg gaa gga aaa gcg cac ctc aat atc aaa agc cca gcg	12074
Leu Gln Glu Trp Glu Gly Lys Ala His Leu Asn Ile Lys Ser Pro Ala	
3970 3975 3980	
ttc acc gat ctc cat ctg cgc tac cag aaa gac aag aaa ggc atc tcc	12122
Phe Thr Asp Leu His Leu Arg Tyr Gln Lys Asp Lys Lys Gly Ile Ser	
3985 3990 3995	
acc tca gca gcc tcc cca gcc gta ggc acc gtg ggc atg gat atg gat	12170
Thr Ser Ala Ala Ser Pro Ala Val Gly Thr Val Gly Met Asp Met Asp	
4000 4005 4010	
gaa gat gac gac ttt tct aaa tgg aac ttc tac tac agc cct cag tcc	12218
Glu Asp Asp Asp Phe Ser Lys Trp Asn Phe Tyr Tyr Ser Pro Gln Ser	
4015 4020 4025 4030	
tct cca gat aaa aaa ctc acc ata ttc aaa act gag ttg agg gtc cgg	12266
Ser Pro Asp Lys Lys Leu Thr Ile Phe Lys Thr Glu Leu Arg Val Arg	
4035 4040 4045	
gaa tct gat gag gaa act cag atc aaa gtt aat tgg gaa gaa gag gca	12314
Glu Ser Asp Glu Glu Thr Gln Ile Lys Val Asn Trp Glu Glu Glu Ala	
4050 4055 4060	
gct tct ggc ttg cta acc tct ctg aaa gac aac gtg ccc aag gcc aca	12362
Ala Ser Gly Leu Leu Thr Ser Leu Lys Asp Asn Val Pro Lys Ala Thr	
4065 4070 4075	
ggg gtc ctt tat gat tat gtc aac aag tac cac tgg gaa cac aca ggg	12410
Gly Val Leu Tyr Asp Tyr Val Asn Lys Tyr His Trp Glu His Thr Gly	
4080 4085 4090	

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ctc acc ctg aga gaa gtg tct tca aag ctg aga aga aat ctg cag aac Leu Thr Leu Arg Glu Val Ser Ser Lys Leu Arg Arg Asn Leu Gln Asn 4095 4100 4105 4110	12458
aat gct gag tgg gtt tat caa ggg gcc att agg caa att gat gat atc Asn Ala Glu Trp Val Tyr Gln Gly Ala Ile Arg Gln Ile Asp Asp Ile 4115 4120 4125	12506
gac gtg agg ttc cag aaa gca gcc agt ggc acc act ggg acc tac caa Asp Val Arg Phe Gln Lys Ala Ala Ser Gly Thr Thr Gly Thr Tyr Gln 4130 4135 4140	12554
gag tgg aag gac aag gcc cag aat ctg tac cag gaa ctg ttg act cag Glu Trp Lys Asp Lys Ala Gln Asn Leu Tyr Gln Glu Leu Leu Thr Gln 4145 4150 4155	12602
gaa ggc caa gcc agt ttc cag gga ctc aag gat aac gtg ttt gat ggc Glu Gly Gln Ala Ser Phe Gln Gly Leu Lys Asp Asn Val Phe Asp Gly 4160 4165 4170	12650
ttg gta cga gtt act caa aaa ttc cat atg aaa gtc aag cat ctg att Leu Val Arg Val Thr Gln Lys Phe His Met Lys Val Lys His Leu Ile 4175 4180 4185 4190	12698
gac tca ctc att gat ttt ctg aac ttc ccc aga ttc cag ttt ccg ggg Asp Ser Leu Ile Asp Phe Leu Asn Phe Pro Arg Phe Gln Phe Pro Gly 4195 4200 4205	12746
aaa cct ggg ata tac act agg gag gaa ctt tgc act atg ttc ata agg Lys Pro Gly Ile Tyr Thr Arg Glu Glu Leu Cys Thr Met Phe Ile Arg 4210 4215 4220	12794
gag gta ggg acg gta ctg tcc cag gta tat tcg aaa gtc cat aat ggt Glu Val Gly Thr Val Leu Ser Gln Val Tyr Ser Lys Val His Asn Gly 4225 4230 4235	12842
tca gaa ata ctg ttt tcc tat ttc caa gac cta gtg att aca ctt cct Ser Glu Ile Leu Phe Ser Tyr Phe Gln Asp Leu Val Ile Thr Leu Pro 4240 4245 4250	12890
ttc gag tta agg aaa cat aaa cta ata gat gta atc tcg atg tat agg Phe Glu Leu Arg Lys His Lys Leu Ile Asp Val Ile Ser Met Tyr Arg 4255 4260 4265 4270	12938
gaa ctg ttg aaa gat tta tca aaa gaa gcc caa gag gta ttt aaa gcc Glu Leu Leu Lys Asp Leu Ser Lys Glu Ala Gln Glu Val Phe Lys Ala 4275 4280 4285	12986
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tta caa ttc att ttc caa cta ata gaa gat aac att aaa cag ctg aaa Leu Gln Phe Ile Phe Gln Leu Ile Glu Asp Asn Ile Lys Gln Leu Lys 4305 4310 4315	13082
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US02/24247

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : C07H 21/00, 21/02, 21/04

US CL : 536/23.1, 24.3, 24.33, 24.5; 514/44; 435/6, 325, 375, 455

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 536/23.1, 24.3, 24.33, 24.5; 514/44; 435/6, 325, 375, 455

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Please See Continuation Sheet**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,220,006 A (ROSS ET AL) 15 June 1993 (15.06.1993), see entire document.	1-56
X	WO 01/12789 A2 (CHAN ET AL) 22 February 2001 (22.02.2001), see page 8, lines 4-17.	1, 11-12, 15

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T"

later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X"

document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y"

document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"

document member of the same patent family

Date of the actual completion of the international search

04 September 2002 (04.09.2002)

Date of mailing of the international search report

05 NOV 2002

Name and mailing address of the ISA/US

Commissioner of Patents and Trademarks
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INTERNATIONAL SEARCH REPORT

PCT/US02/24247

Continuation of B. FIELDS SEARCHED Item 3:

CAplus, Medline, Biosis, USPatfull, EPO, JPO, Derwent

search terms: antisense, aptamer, triplex, AS-ODN, oligonucleotide, or ribbozyme, (ApoB or apolipoprotein B), and ApoB-48